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RAPID METHODS IN DRIVING ALPINE TUNNELS

By Walter I. Aims.*

Records of speed attained in driving rock tunnel headings show that the progress made in Alpine tunnels has far exceeded the best American records, and it therefore becomes a matter of considerable importance to determine the reasons why so great a difference should exist.

The best American record is now claimed for the Elizabeth Lake tunnel of the Los Angeles aqueduct work, where 466 feet is said to have been driven in a single heading during October, 1908. But even this record falls far short of that made at the Simplon tunnel in the Alps, where 685 feet was driven in one heading during July, 1904.

The writer has recently visited the Loetschberg tunnel now being built between Kandersteg and Goppenstein near the line of the Gemmi Pass, Switzerland. It is on the line of the railway to connect Berne with the Simplon tunnel road to Italy. In this tunnel similar monthly progress to that made at the Simplon is now being accomplished, and the results of the writer's observations are herewith appended.

This tunnel when completed will be about 8½ miles long. Near the northern portal the tunnel passes under the Kander River and it is at this point that the serious cave-in, extending up to the river bed, occurred last July. This accident occasioned the temporary abandonment of work in that heading until plans shall have been decided upon for meeting this difficulty. The work, therefore, is at present being carried on from the southern portal only.

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The experience gained in driving the Simplon tunnel is being used to advantage at the Loetschberg, with the difference, however, that while the Simplon was driven with rotary drills of foreign manufacture, the Loetschberg is being driven with American air driven per-

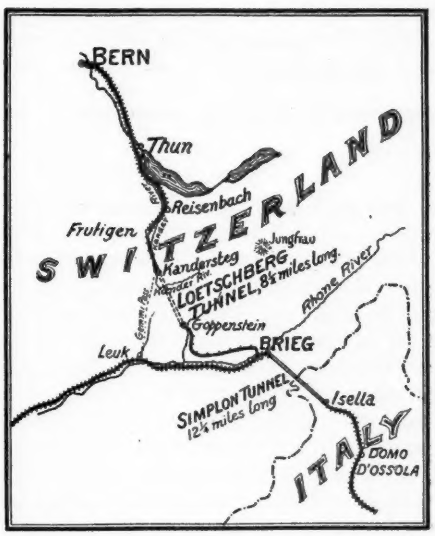


FIG. I.—LOCATION OF TUNNEL.

cussion drills made by the Ingersoll-Rand Company.

The tunnel is designed for a double track railway and has a cross-sectional area of about 66 square yards. The bottom heading method of construction can therefore be used to advantage. This bottom heading is about 6 feet 6 inches high by 10 feet wide. Every 600 feet upraises are made from the bottom heading and a top heading started from each of these upraises. From these top headings the work of taking out the tunnel to its full section is

carried on in bench work, timbering being erected in the bottom heading during the later stages to prevent the shell of rock between the top workings and the bottom heading breaking through and thus blocking the track below. As soon as these top excavations are connected with the bottom heading the timbering is removed to be used again at another point. The sides are then trimmed out and the concrete lining is placed, largely made up of beton or concrete blocks backed with concrete.

There is but a single track in the bottom heading about 2 feet 6 inches gage, with turnouts every 600 feet where the upraises occur, the bottom heading being widened out at these points to accommodate the turnouts. Numerous chutes about 2 feet square are also blasted out between the bottom heading and the top workings through which the muck is dumped into the trains of cars in the bottom heading.

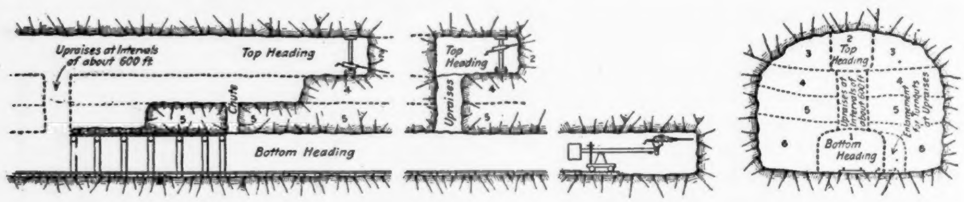


FIG. II.—METHOD OF ATTACK AND SEQUENCE OF OPERATIONS.

By this method of working, there is no difficulty in keeping pace with the heading, and in taking out the full tunnel section; at the same time no delay is occasioned to the heading operations. The speed of the heading, therefore, is the speed of the completed tunnel and hence it is the methods used at the heading upon which the main interest centers.

The secret of the great speed in these Alpine tunnel headings appears to be that a very careful study has been made of the various causes of delay in the successive operations of drilling, blasting, mucking out, and setting up the drills again, with the result that a radically different method of mounting the drills in the heading has been employed and also that a different system of blasting is used from that practiced in America.

In the mounting of the drills, the return to the old drill-carriage idea is disclosed; but in this instance there is no such cumbersome affair as the drill carriage used in the early tunneling operations in this country.

The drill carriage at the Loetschberg simply consists of a small truck with a wheel base of about 4 feet running on a regular heading truck. Mounted on this truck and hinged to swing vertically, is an I-beam reinforced to give it lateral stiffess. On the forward end of the I-beam there is mounted what we in America would call a shaft bar, pivoted to swing horizontally. On the opposite end of the I-beam is a counter-weight. Four drills ("F. 94") are mounted on this shaft bar, the compressed air connections from these drills running back to one hose connection at the rear of the truck. The accompanying cut illustrates the main features of the drill carriage. When not in use the shaft bar is swung so that it lies directly over the I-beam, and the carriage can then be run anywhere over the heading tracks, occupying no more room in the heading than a couple of muck cars.

Before blasting a plate of steel about 6 feet 6 inches long, 3 feet 3 inches wide and 3/8 inches in thickness is laid down just ahead of the end of the track. After the blasting is over, a cut is quickly made through the center of the muck pile down to this steel plate sufficiently wide to allow the arm of the drill carriage to introduce the bar carrying the drills into the top of the heading, the drill carriage running on the steel plate laid down ahead of the track. The bar is then firmly jacked against the sides of the heading and drilling immediately begins on the top holes. Mucking out then continues during the drilling.

On account of the drills remaining on the drill carriage at all times with the air connections at the drill undisturbed, there is little chance for dirt and grit to get into the working parts of the drill and so impair its efficiency. The drills are of large size, having a piston diameter of 3-5/8 inches and are designated in the catalog of the manufacturer as "F-94".

There are from 2 to 4 holes drilled in each round for taking out the heading. These holes

have a depth of 4 feet and are 2 inches in diameter at the bottom. They are arranged in four vertical rows, the two center rows corresponding to our center cut and two outer rows to the side round. The two center rows, however, are not pointed to form a V as is the custom in America, but are run in more nearly perpendicular to the face.

The rock so far encountered varies from granite to gneiss and is hard drilling. The compressed air for the drills is furnished by two Ingersoll-Rand compressors of the cross-compound two stage type, electrically driven and giving a pressure of from 90 to 100 pounds per square inch at the drills.

exploder would fill a long felt want, but while several attempts have been made to manufacture such an exploder, nothing of the kind has as yet been devised that has proved to be a practical success.

The work at the Loetschberg is carried on in three 8-hour shifts and each shift is expected to drill two rounds and to shoot twice, making about 7 feet per shift, or 21 feet per day. A liberal bonus is paid to the men for all speed made above a certain rate. The workmen are Italians, nearly all from the Northern provinces. The following table gives the approximate time for the various operations in the heading:

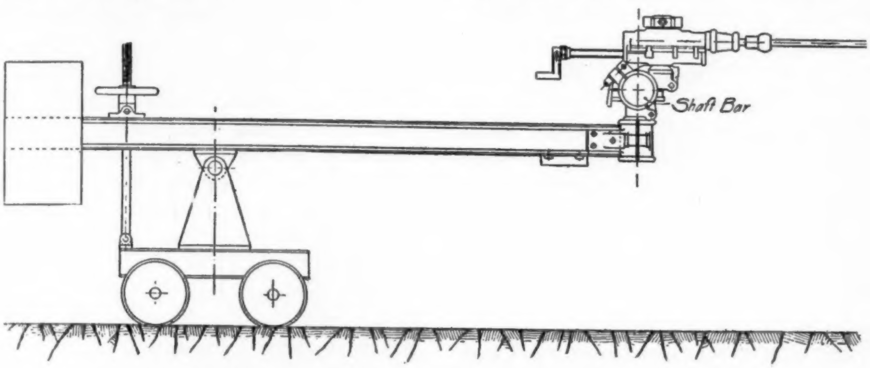


FIG. III.—DRILL CARRIAGE USED IN HEADING.

As soon as the round is all drilled, the drill carriage bearing the four drills is run back to the last turnout and blasting begins. Blasting at the Loetschberg tunnel is done by the fuse-and-cap method of exploding the charge. All of the holes are loaded and the fuses of all of them are ignited at the same time, but by a careful regulation of the length of these fuses a series of minor explosions occurs, so arranged that all of the center holes are exploded before the side holes.

More powder must necessarily be used in firing in this manner, but the advantages gained are as follows: less time is consumed in blasting; the rock is broken up more uniformly; and the effect of the blasting is less severe on the track than when the system of electrical firing is employed. There is one drawback to this method of firing by fuse-and-cap, *viz.*, the danger arising from missed holes. An attempt is made to minimize this danger by employing two fuses in all holes except those at the bottom, where three fuses are introduced.

It would seem that an electrically fired time

Setting up drill carriage in the heading	20	minutes
Drilling 12 or 14 holes	60	"
Removing drill carriage from the heading	20	"
Loading and firing the holes	30	"
Clearing out the smoke	20	"
Making cut through center of muck pile for carriage	90	"
Total	240	minutes
	or 4	hours

Ventilation is provided by means of a large fan, capable of running either as an exhauster or as a blower. From this fan a spiral riveted pipe 2 feet in diameter runs through the bottom heading. The tunnel is lighted with acetylene lamps carried by the miners. Each man is required to buy his own lamp and to keep it in good working order. The light is brilliant and always at the point where it is wanted; and there are no delays such as those aris-

ing from broken or disarranged wires where electric lighting is employed.

The difference between the methods used at the Loetschberg tunnel and those employed at home are most striking and interesting. Perhaps when the time comes for Americans to break away from the present established methods in driving rock tunnel headings, improvements and new ideas may enable us to equal and even to exceed the records made in Alpine tunneling.

WHY NOXIOUS WEEDS ARE DESTROYED BY CHEMICAL SPRAYS

BY PROF. E. W. OLIVE, SOUTH DAKOTA STATE COLLEGE.

During the past summer the writer carried on experiments with weed spraying in various parts of South Dakota, and to him one of the most interesting problems connected with the work has been that which concerned the way in which the chemical affected the sprayed plants.

I will attempt to describe briefly just why it is that, while mustard and most other common weeds are totally destroyed by the chemical solution, the wheat, oats, barley, flax, etc., are themselves but little if at all injured. This may sound almost like a patent medicine advertisement, but it is nevertheless true that the grain soon recovers from the effects of the treatment, while the weeds, on the other hand, are nearly all killed.

The method of applying the solution for weed killing in grain fields is already familiar to many. The field is carefully gone over with a traction spraying machine, and thoroughly treated with a strong solution of iron sulphate (about 20 per cent., or one sack of about 100 pounds to a barrel of water). The machine which gave the best satisfaction in our experiments covered a swath about twenty-five feet wide, and threw a very fine and powerful spray, under a pressure of from 80 to 120 pounds, directly down on to the young mustard and grain. Practically that amount of pressure is necessary in order to develop the proper fineness of spray as the solution is vented from the nozzle.

As has been borne out by the experiments in other states, the spraying is most effective if done when the grain and weeds are from 6 to 10 inches high; or just before the mustard plants begin to bloom. Also, it is highly important that the work be done during favorable weather. The necessity for this will be understood when we come to consider the physiological reasons for the killing of the weeds. The time when the most successful work is done is just after the dew is off, on a bright, sunshiny day. A little wind will also help the drying process; but if a rain follows too soon, the iron salt is washed off and all the work comes to naught.

Now, if we keep close watch of the sprayed weeds, we can readily follow the various steps of the destructive action of the salt. First, the sulphate dries on the leaves, leaving minute whitish flakes on the surface. This quick drying is apparently an absolutely necessary step in the process; if the day be cloudy, or if through other unfavorable conditions evaporation from the leaf surface is prevented, the weeds may not be killed at all, or at least only partially destroyed.

The next step may be noticed in about two or three hours. If we now examine such succulent plants as mustard, we see on close examination that the leaves show many scattered, more or less translucent, sunken areas, some as much as a quarter of an inch in diameter, other quite small. The leaves by this time appear to be somewhat wilted, and the whole plant looks sick.

Two or three hours later comes the next change. The sunken areas have by this time nearly all turned black, and if these spots are examined through a microscope, it is seen that it is the contents of the shrunken cells which turn black. The leaves from now on wilt rapidly and dry up, so that in twenty-four hours or so they seem to be about dead. In from a few days to a week, most of the mustard leaves fall off, or else remain as dry, withered remnants on the dead stems.

Occasionally a leaf may make a weak attempt at revival; or a plant here and there may make a futile effort at flowering and seed production. But if the work be thoroughly done, few weeds survive the treatment. I have seen mustard so thick as to approximate 100 plants to the square foot, all totally destroyed by spraying.

From the above description of the various steps in the dissolution of a sprayed leaf, the interpretation of the physiological action of the sulphate seems clear. The main process involved seems to be that the water in the leaf is drawn out of the cells by the flakes of salt dried on the surface. Common salt, when sprayed on mustard, ragweed, or most other weeds, in the form of a very strong solution, apparently acts in a manner precisely like that noticed as a result of spraying with sulphate of iron, only its action is even quicker. Of course the plants are going to wilt and die if practically all the water is drawn out of their leaves. The subsequent blackening probably comes from the formation of sulphides in the cells of the leaves, due to the union of some of the absorbed iron sulphate with the living substance.

Now the most interesting question of all remains to be answered: Why are the weeds killed and the grain uninjured? Anyone may answer this question for himself if he will only examine a sprayed field closely, a few days after the spraying has been done. It will be seen, of course, that the grain does not entirely escape injury. The tips of the young leaves are nearly all blackened and killed; but it will be remembered that, when the grain is only six inches to a foot in height, the bases of most of the leaves are well protected, enwrapped within the sheaths and lower leaves. Therefore the spray strikes only a small part of each leaf.

While the grasses and grains thus suffer a little setback, they soon pick up again. They owe their freedom from permanent injury, undoubtedly, to their habit of indeterminate growth, as well perhaps as to the fact that their smooth surfaces shed the water. The minute droplets of the iron sulphate or salt do not adhere readily to the surface of flax, for example, on account of the waxy bloom which covers the plants; and many other grains (and some weeds, too, for that matter) are likewise provided with such a protective covering.

The highest mine in the world is the Santa Barbara, Bolivia, South America, which is at an altitude of 18,000 ft. above sea level.

PRACTICAL HYGROMETRY

By J. H. Hart.

[The following is presented, in a more or less condensed form, from the columns of *Power and the Engineer*].

The wonderful adaptation of mechanical refrigeration in the removal of moisture from the blast in iron furnace operation, and its consideration in the operating of cooling towers, and also the possible application of mechanical refrigeration to the drying of blasts of any kind and wherever used, have brought the subject of moisture in the atmosphere to the notice of the practical engineer.

Hygrometry determines the quantity, always variable, of aqueous vapor in the air. The atmosphere is seldom, if ever, completely saturated with vapor, and never completely dry. The ratio of the quantity of acqueous vapor actually present in the air to that which it would contain if saturated, the temperature being the same, is called the hygrometric state, or the degree of saturation.

ABSOLUTE MOISTURE IN THE AIR AND ITS VARIATIONS.

The absolute moisture in the air is the weight of water actually present in the form of vapor in the unit of volume. There is this remarkable fact about vapors in general. Two vapors, or a vapor and a gas, will occupy the same place just as if the other were not present. [That is, each will occupy its own amount of space independently of the amount of space occupied by the other. Ed. C. A.] Thus water vapor is present everywhere in the space surrounding the earth, and the quantity of this vapor depends simply upon the temperature of the vapor and its contiguity to a source of the liquid. If immediately in contact, it in general becomes saturated for that temperature in precisely the manner that steam becomes saturated in a boiler, and remains so. A saturated vapor in this department has the same significance as a saturated vapor in steam or ammonia work. It means that if the pressure is increased or the temperature lowered, condensation occurs, or in other words, that the space contains all of the vapor possible at that pressure and temperature. Thus the space surrounding the earth

contains water vapor independent of the quantity of air present.

Absolute moisture in the air varies with the temperature in the course both of the year and of the day. If summer, there is a maximum in the morning and evening and a minimum at 3 a. m. and 3 p. m., because of the ascending current of air which carries the moisture upward. The absolute moisture is greatest in the Tropics, where it represents a pressure of 1 inch of mercury, while in our latitude it does not exceed 0.4 inch. The relative moisture, however, is on the average greater in high than low latitudes. It is at its minimum in the hottest and at its maximum in the coolest part of the day. It varies in different regions, and is greater at a distance from a large body of water than when near at hand. Thus in England the relative moisture is about 80, in Italy about 60 and in Siberia about 40 per cent. When the air is cooled, the relative moisture increases until it ultimately becomes saturated. This accounts for the production of rain and dew and snow. They are invariably due to the cooling of the atmosphere below the saturation point of the aqueous vapor present.

SENSIBLE HUMIDITY.

Our judgment in regard to relative humidity varies greatly. In summer we say that the air is very dry when it contains an average of 1/40 of a pound of water to the cubic yard, as it could then contain twice this amount without condensation. On the other hand, in winter if the same volume contains 1/80 of a pound, we say it is very moist, because it is very near the saturation point and a very slight diminution in temperature produces a deposit. When a room is warmed, the quantity of moisture is not diminished, but the humidity of the air is lessened, because its saturation value is raised. The air may thus become so dry as to be injurious to the health, and hence arises the precaution of placing vessels of water in such a room.

RATIO OF PRESSURES RATHER THAN QUANTITIES.

Boyle's Law applies to non-saturated vapors as well as to gases, and the presence of another gas or vapor has no effect on the operation of this law. Hence, it follows that, with the same temperature and volume, the weight of vapor in an unsaturated space increases with the pressure and, therefore, with the pressure of the vapor itself. Instead, therefore, of using the definition of hygrometric state as the ratio of the quantity of vapor present to the quantity of vapor present in a saturated state, it can be defined as the ratio of the pressure of the vapor which the air actually contains and the pressure of the vapor which it would contain at the same temperature if it were saturated. Thus if f is the actual pressure of the aqueous vapor in the air, F that of the saturated vapor at the same temperature and N the hygrometric state, we have

$$N=\frac{f}{F},$$

whence

$$f=F\,N.$$

As a consequence of this second definition, it is important to notice that, the temperature having varied, the air may contain the

RELATIVE HUMIDITY.

same quantity of vapor and yet not have the same hygrometric state, for when the temperature rises, the pressure of the vapor which the air would contain if saturated, increases more rapidly than the vapor actually present in the atmosphere, and hence the relation between the two forces, or the hygrometric state, becomes smaller.

PRESSURE, TEMPERATURE AND CONDENSATION.

This relation N is what is generally measured in the majority of hygrometers. Given this value and the pressure and temperature obtainable from other sources, the absolute moisture in the air, or the quantity of water present, can be calculated by suitable formulas. The absolute quantity of water present in the air can also be attained directly by what is known as a chemical hygrometer. This consists of some hygroscopic substance which is weighed and then made to absorb all the moisture in a certain quantity of air. It is then reweighed and the quantity of moisture obtained by subtracting. This gives abolute values. and is the only thing of much importance in refrigeration work in the removal of moisture from the air. The only necessary factors to consider in a problem of this kind are: The quantity of air which must be furnished, the quantity of moisture that it contains and the temperature to which

both must be cooled in order to condense moisture.

It is obviously impossible to cool the air to a sufficent extent to remove all the moisture if no limitations of pressure are considered, but in practice, with suitable pressures and temperatures, it is possible to condense almost the entire amount. The amount condensed for a given temperature depends primarily upon the pressure, and thus, in different applications of blast operation, different cooling temperatures must be maintained. The removal of the moisture from the air blast in iron-furnace operation increases the production of the iron, on account of the saving in heat and its concentration in the furnace. Water vapor has a high specific heat and, when injected into the furnace, absorbs large quantities of heat in its passage. Further, a process analogous to that in the production of water gas goes on and the water vapor present at this high temperature is decomposed with the subsequent loss in the furnace of its heat of decomposition. This decomposed material unites with carbon partially and goes on into the exhaust, where it gives up its heat by recombination and further increases the heat waste in the exhaust. It is analogous in this respect to the nitrogen present in the air, but is tenfold as destructive in its effect. The cooling of the air is lost in the furnace, since the air must be reheated, and further, the degree of cooling affects the efficiency of the refrigerating device; hence, all of these factors must be considered in determining the degree to which air must be cooled, and no fixed values can be given. Sufficent data are not at hand and results can only be obtained from practice.

BEHAVIOR OF WATER VAPOR IN AIR.

Of course it goes without saying that air can be cooled more efficiently from a practical point of view when under pressure, and the process of removal of the moisture continued more efficiently; but the behavior of the water vapor during compression of the air is an important factor and also enters to disturb results for best efficiency. The best method of considering the behavior of water vapor in air and its effect on efficiency, is to regard it separately in all its changes. Thus when air is compressed and has water vapor in it, we can get the best conception of the results by regarding each material as separated and the process performed in this state followed by a recombination. Thus water vapor, if separated and compressed, will condense partially, if not heated at the same time, and a consideration of the phenomena that occur under these conditions shows results exactly similar to those holding in steam work. In general, with increase in pressure on a condensable vapor at its saturation point, there results a considerable condensation which gives out its heat of liquefaction. If air is compressed, the work done in it heats it somewhat, and the presence of water vapor, also compressed, heats it still more on account of the condensation of the water. The mixture of water vapor and air may be heated to such an extent as almost to evaporate the water again, but the general result is to increase the working pressure of compression, thus diminishing the efficiency of the plant.

AIR A CONVENIENT CARRIER FOR WATER VAPOR.

In general, the whole phenomenon of moisture in air and its application can be best considered by regarding the moisture as occupying the space independently of the air present. Thus in cooling towers and drying devices of all kinds, advantage is taken of the fact that an unsaturated vapor tends to become saturated when immediately in contact with a liquid of its own substance, and tends to remain so. In cooling-tower work we can neglect the presence of the air and regard the space surrounding the cooling tower as filled with water vapor, in a more or less saturated condition. The presence of the air is an advantage from a mechanical point of view, simply by furnishing a convenient carrier for the water vapor, or by offering something by which the water vapor can be conveniently held and moved, so that the efficiency of a cooling tower depends absolutely on the quantity of saturated vapor which can be brought into immediate contact with the water, and this depends, within certain limitations, upon the quantity of air which can be brought under the same conditions and upon the surface of the water to be cooled. A great mistake is often made in cooling-tower practice by using fans to drive the air rapidly through

the entire length of the tower. The air is merely a conveyor of the unsaturated water vapor. This becomes saturated almost immediately upon contact with the first layer of water in the tower and the further progress of this saturated vapor, and the air which drives it, is a distinct economic loss in the operation of the plant.

WARM AIR FOR COOLING TOWER.

Today it is generally recognized that atmospheric cooling towers are much superior, from an efficiency point of view, to those operated by fans. A mistake is often made in this practice by not considering the temperature of the substances involved. Unsaturated water vapor which has been heated requires a greater additional quantity of water to make it saturated. Hence it is much better to use warm air in a cooling tower than cold, anomalous as this statement may appear. The cold air does cool off the hot water to a certain extent by conduction and contact with its surface, but air is notoriously a poor conductor, and hence the advantage derived from this factor is very small. Hot air means that the water vapor is hot also and less saturated than before, if such a term can be used, and the relative humidity *N*, is much less. This is a point which should not be lost sight of in cooling-tower work, or drying work of any kind, and modern practice seems to bear out this statement.

The utilization of superheated steam as a drying agent is a distinct example of this development. Superheated steam, although very hot when allowed to go over moist materials, rapidly absorbs the water from them and actually cools them below their former temperature, although the amount is nowhere near as great as in cooling-tower practice, since the water vapor in contact is a fairly good conductor of heat.

PRESSURE AND GAGE CONDITIONS

"The trouble with me is that I know too darn much," drawled the puzzle editor as the chief passed his desk.

"How so?"

"Didn't you ever notice that the less a man knows about a thing the quicker he can give you an answer about it? For instance, here is a fellow who wants to know what is the difference between the gage pressure and the absolute pressure. I was on the point of telling him 15 pounds. If your gage pressure is 75 pounds, the absolute pressure is 75+15=90 pounds. That is good enough for most cases, and more exact than men ordinarily read gages or than gages usually are, but I happened to think that the fellow may use Kent's table, where the gage pressures are all given with an 0.3 after them and the gage pressure corresponding with 90 absolute is 75.3. So I start in to tell him to add 14.7 to the gage pressure to get the absolute, and then it struck me that this is only right if the pressure of the atmosphere is 14.7 pounds, and if it happens to be so it is an accident. I can tell him to add the pressure of the atmosphere to his gage pressure, but how is he going to get the pressure of the atmosphere? If he takes it by the barometer, it will be right for that place and time, but may not be right for another place or another time or for the case that he is working on. And then he gets it in inches of mercury and he has to use it in pounds per square inch. No two authorities agree as to the weight of a cubic inch of mercury and it is dollars to doughnuts that he wouldn't have pure mercury in his barometer, and the weight per cubic inch varies with the temperature, which he would not know, and then again a cubic inch of pure mercury at the same temperature weighs less at the equator than it does at the poles on account of the centrifugal force, so that the latitude comes in. Gee, I could write a book about it. If I only knew half as much my work would be twice as easy."—*Power and the Engineer.*

CLIMATIC RANGE OF ATMOSPHERIC TEMPERATURE AND HUMIDITY*

By F. Z. Schellenberg.

The high temperature of 147 deg. F. for the air in the open, found on the sandy soil of Lake Erie, in the sun, is reported by botanists studying the habitat of Pennsylvania flora.

The record extremes of temperature in the shade at Pittsburg are 20 deg. F. below zero (Feb. 10, 1899) and 103 deg. above zero (July 10, 1881). Our average temperature through the year is 53 deg. The first frost is

*Journal of the Society of Engineers of Western Pennsylvania.

about Oct. 20, and the last April 20, just a month after the fall and spring equinoxes. It is remembered, however, that fifty years ago (1856 and 1859) killing frosts came in June, destroying the wheat crop within one month of its harvest time.

At zero Fahrenheit air is saturated with half a grain of moisture to the cubic foot, at 15 deg. with one grain, at 32 deg. with 2 grains, at 50 deg. with 4 grains, at 62 deg. with 6 grains, at 70 deg. with 8 grains, at 85 deg. with 12 grains, at 100 deg. with 20 grains, with a gradual reduction of density of the air amounting to one-fifth.

In the table following, from the Weather Bureau's observations at Pittsburg, for 31 years to end of 1903, the mean of the daily and then of the monthly is divided only for the four seasons, December 1 to November 30 as maxima and minima averages to reach the seasons' and the years' mean for the whole period: For the temperature in degrees Fahrenheit; precipitation in inches; and humidity of the air in percentages of full saturation and in grains absolute.

table, but by years with the extremes 25.73 (1900) and 50.61 (1890) we have the mean annual total rainfall 36.38 inches.

Humidity ranges in the averages between 62 per cent. in summer and 81 per cent. in winter, with more absolute moisture (5.83 grains to the cu. ft.) in the former than in the latter (1.63 grains) and accords with the common belief that near three-fourths of one per cent., 50 grains of water in the pound of air, is the upper limit desirable for the free perspiration of the human body that tends to comfort under moderate exercise in fair weather.

The proper moisture in the air according to, and with mild, temperatures concerns keenly the workers in confined spaces, and should be parallel with ventilation, the prime object of which is the giving of pure air with its normal content of but .03 per cent. of carbon dioxide.

ANKYLOSTOMIASIS

This is a disease occurring among miners but not confined to them, being common among laborers in tropical countries, even field workers suffering from it. It is an intestinal disease due to the presence of a worm *ankylostoma dirodenale* in the upper intestine. The disease may be contracted in mines where in the damp and dirty conditions and the warm air the parasite multiplies rapidly when once introduced. The disease is acquired by miners while eating by swallowing larvae which get on their hands, and also by the worms passing through the skin, causing temporary eruptions. The symptions of the disease are quite similar to those of anemia.

SEASON	Temperature in Deg. Fahrenheit		Precipitation Inches		Humidity Ranges	
	Mean	Maxima-Minima	Mean	Minima and Maxima	Saturation Per cent	Absolute wt. Grains Per cu. ft.
Winter.....	33	40-25	8.5	6.4-15.3	81-74	1.63-1.72
Spring	51	61-41	9.4	4.9-14.6	76-85	2.86-3.08
Summer...	73	83-63	11.4	7.4- 9 7	76-62	5.69-5.83
Fall.........	55	65-46	7.5	6.8-11.0	79-65	3.35-3.53
Annual....	53	62-44	36.8	25.5-50.6	78-66	3.38-3 54

SEASONS' CHANGES IN TEMPERATURE AND HUMIDITY.

For temperature, the seasons' grand average minimum is 25 deg. and maximum 83 deg., and giving the seasons' mean equal weight would make the years' 54 deg., but the annual reach is finally between 44 deg. and 62 deg. for the series and gives 53 deg. as the average, nearly which (52.9) the annual is too from the years' averages summed by months' averages. The highest annual average (1900) is 54.7 deg., the lowest (1875) is 49.0 deg.

For precipitation we get the mean annual rainfall 36.8 inches through averages as in the

A SIMPLE WOOD PRESERVING PROCESS

For several years the Forest Service of the U. S. Department of Agriculture has been experimenting with a method of impregnating wood, which requires no expensive equipment, is simple in operation, and is adapted to a plant of any desired capacity. It is now known that all of the more porous woods can be treated successfully by this method. The method is called the "open tank" or "hot and cold bath" process. The impregnation is accomplished by thoroughly heating the timber in a tank containing a liquid substance, then running off the hot liquid and filling the tank with cold, or transferring the timber from a tank containing hot to a tank containing cold liquid, or allowing the whole to cool without change.

The theory of the process is that the air in the wood cells and intercellular spaces expands when heated and is partially expelled. Upon cooling, it again contracts, thus causing a partial vacuum, and the pressure of the air on the outside forces the liquid into the wood. The process may be applied with any of the preservatives in common use; as for instance, creosote oil and zinc chlorid solution. The principle is the same whether the treating is done in a small tank holding a few fence posts and heated with a wood fire underneath, or in larger tanks fitted with steam coils for heating, pumps for handling the oil, and labor saving devices for handling the timber.

The result of the government's extensive experiments in wood preservation are published in circulars and bulletins, which may be had by all interested persons who address the Forester at Washington, D. C.

GERMAN COMPRESSED AIR MINE LOCOMOTIVES

We illustrate on these pages a type of compressed air locomotive introduced by the Berliner Maschinenbau-Actiengesellschaft, Figs. 1 and 2 being end and side outline elevations respectively, not to the same scale, and the half

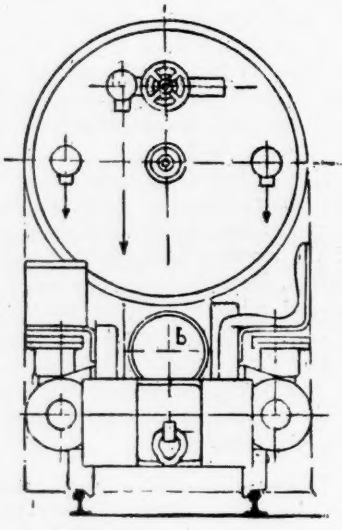


FIG. I.—END ELEVATION.

tone Fig. 3, showing a locomotive in actual service and stopped at a charging station for a fresh supply of air.

The standard pattern of the machine is of 8 to 12 nominal h. p., but is capable of working

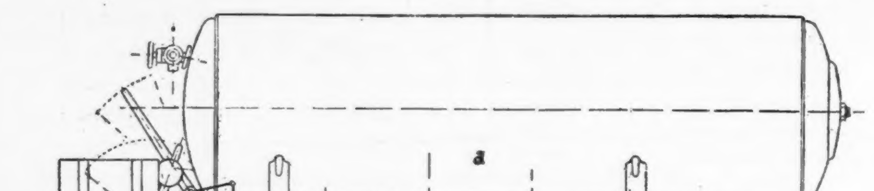


FIG. II.—SIDE ELEVATION.

up to 24 h. p. as a maximum and, under ordinary conditions of gradient, will haul about 40 full tubs, each with a net load of 11 cwts., at a speed of 5 1-2 miles per hour. It will run a distance of about 1,600 to 3,200 yards with

a single charge of air, the pressure sinking from about 750 lbs. per square inch to 150 lbs. Even under the latter conditions, however, the engine can run empty for another 1,500 to 2,000 yards, so that the driver can easily reach a recharging station should the locomotive be unable to haul the train at any point of its course.

The dimensions of the locomotive are as follows:—Total length over buffers, 13 ft.; maximum height above the rails, 5 ft.; maximum width, 3ft.; wheel base, 40 in. With these dimensions curves of 33 ft. radius can be negotiated without difficulty. The effective adhesion weight of the locomotive is about 5 1-2 tons, so that it is capable of exerting considerable tractive force, even on greasy rails, without slipping.

FIG. III.—LOCOMOTIVE AT CHARGING STATION.

As shown in Figs. 1 and 2, the locomotive consists of the main air receiver, *a*, auxiliary receiver, *b*, the motion, *c*, and the frame, *d*, with the requisite valves and fittings, including safety valves and pressure gauges for both air vessels, a reducing valve, signal bell, sanding appliances, powerful brake, lamp, etc. The driver's seat is above the driving cylinders, and all parts of the motion are easy of access. The air supply is compressed to 1,125 or 1,500 lbs. per square inch, and stored in reservoirs. These are connected by air mains with charging reservoirs (Fig. 3), situated at convenient places for recharging. This latter operation is effected in a very short time; in fact, it is claimed that 1 to 1 1-2 minutes will be sufficient, on account of the high pressure in the recharging cylinders. The difference between the pressure of 750 lbs. in the locomotive air cylinder and 1,500 lbs. in the compressor equalises the work of the latter so that it can be kept running continuously even when the loads to be hauled are subjected to considerable fluctuation. In the event of the compressor supplying more air than is being consumed by the locomotives, an automatic valve on the former opens and allows the compressor to run empty until the pressure in the reservoirs has fallen below the limit of 1,500 lbs.

The working pressure in the engine cylinders is lowered to 150 lbs. by a reducing valve of special design, the air being passed through an auxiliary air chamber. An early cut-off enables the expansive power of the air to be fully utilized.

Railroads use in their locomotives one-quarter of all the coal mined in the United States, and fuel is the largest single item of expense in conducting transportation.

STEAM VS. COMPRESSED AIR IN MINING

The following we take from a paper by Mr. John Unsworth, before the National [British] Association of Colliery Managers:

As to the comparative values of steam and compressed air, it would appear on the face of the matter that it must be more advantageous to use steam direct, than to convert the steam power into compressed air power. It is, of course, patent that in the latter process you lose by friction, and in other ways, a considerable portion of the steam power, and this loss is variously stated to range from 25 to 50 per cent.; indeed, I have heard it stated that the loss may, and sometimes does, reach 60 per cent. My own experience, however, goes to prove that with the best type of air compressor, and using large pipes for conveying the compressed air from the compressor to the hauling engine, pump, or other machine which is driven by compressed air, the loss is always under 25 per cent.

There can be no question that compressed air is available as power *under all conditions,* while steam and electricity can only be applied under special conditions. Where you have furnace ventilation you may, if your steam boilers are in the mine, utilize the fuel used under your boilers as an adjunct to your furnace, and in this way effect a saving in your coal consumption for furnace purposes; but steam cannot be used except with a great deal of trouble and expense far away from the pit bottom.

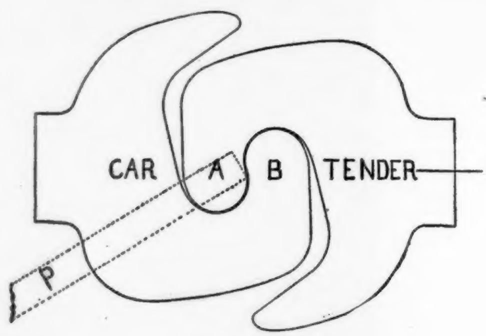
Taking everything into consideration, I am obliged to say that, in my own experience, I have found compressed air much more convenient, as a motive power, than steam, and on the whole not much, if any, more expensive. Mechanical power for other purposes in the mine has progressed during the last half-century, from *nil* to a very large quantity. Pumping, coal-cutting, and belt conveyors for carrying coal from the face of the mine to the haulage or other main road, are all done now by power of one or other of the classes referred to.

It is said that in the stripping of the heavy over-burden in its ore properties on the Mesaba Range the United States Steel Corporation is handling about as much earth as is being shifted at the Panama Canal.

VACUUM A PUSH AND NOT A PULL

The following, from the Locomotive Firemen and Enginemen's Magazine, should settle it for all time about the action of a vacuum:

In the air brake car, the other day, the instructor had just finished explaining the action of the air pump to several young firemen who were somewhat slow in understanding the business that transpires in the air end. Realizing that he had a good-sized audience of enginemen that had drifted in, and who seemed interested in his demonstration, the instructor



A PULL IS A PUSH.

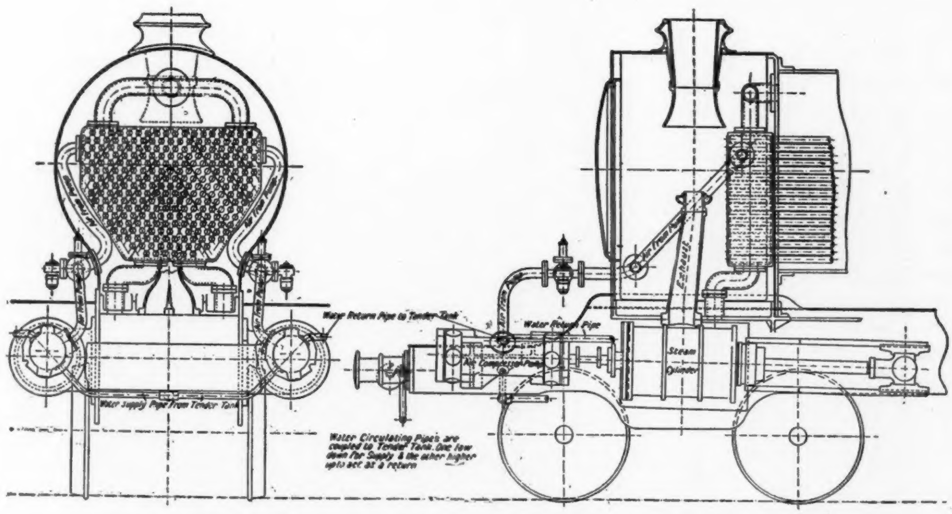
observed: "Gentlemen, there is no such thing as *suction,* nor *pulling;* those words are proper to use in their common application, but they refer to movements of matter that are inspired in exactly an opposite manner to that suggested by the terms as used."

"Huh!" remarked Hank Ely, "the last quarterly dividend on Air Line Stock was made possible by the freight tonnage that the 259 persuaded up an' over the hills o' this yere pike, an' she's always connected onto the head end of the train. I sort o' 'lowed she was doin' some tall pullin', especially up Summit, but I see I was mistaken. An' when a drawbar is extracted from the end of a car *I push it out!* Yes, I see. An' *they ain't no suction!* When the reverse lever's in the one-an'-only notch, ask Daly what snatches the coal off'n his shovel 'fore he gets it through the firebox door; I used to think it was the suction resultin' from the blast of the exhaust steam in the front end—but that was foolish of me."

Hank's an amusing soul, and the instructor laughed with the rest; then he said: "Well, I could show you that at every point of the application of force in the motion work of the engine the effect is *a push;* but we'll take up the

question of the engine pulling the cars—as you have termed it. Here is a sketch of the couplers on the hind end of the tender and front end of the first car of the train;" and he chalked up a rough drawing of a pair of coupled drawbars, like this:

"With the locomotive moving forward," the instructor explained, "the tender coupler shown in the sketch is carried to the right and in engagement with the car coupler the car is impelled to the right. The coupler knuckles, *A* and *B*, sustain the resistances between force and inertia, and their inner faces at the points of contact is where the energy supplied to knuckle *A* of the tender coupler from the motive power of the locomotive is transmitted to knuckle *B* of the car coupler; and I will leave it to any one present:—doesn't knuckle *A* *push* against knuckle *B*?



LOCOMOTIVE USING SUPERHEATED STEAM AND COMPRESSED AIR.

SUPERHEATED STEAM AND COMPRESSED AIR

The combined use of air and steam in fluid pressure engines is by no means a new idea; proposals to carry it out in various ways have been made at intervals for the past fifty years or more, and there have been a few experiments in this connection in years gone by; but so far as we are aware the only apparatus of this class which has proceeded beyond the purely experimental stage, and of which there are several in actual work, is that devised by Messrs. Field and Morris and introduced by the New Century Engine Company, Limited.

The thermodynamic virtues of compressed air and the general characteristics of steam are, of course, well known; but the condition of affairs when the two fluids are mixed and superheated together is not so clear, and it is necessary to deal more with the facts as they occur in actual practice than with theory on its own merits. According to this system an air compressor is employed, this being usually run by the engine to be operated, and the air is supplied, preferably at a pressure substantially the same as that of the steam, to a superheater to which the steam is also supplied, the two fluids intermixing and being together superheated, after which the combined fluid, or "aërated steam," as it is sometimes termed, is used in the engine cylinders.

The compression of the air, of course, entails the expenditure of energy, and this is necessarily, debited against the actual output of the engine itself; but in consequence partly of the fact that some of this energy is converted into heat, and partly for reasons which can only be guessed at or theorised upon, it has been found in practice, we understand, that the work lost in compressing the air is more than made up for by the increased efficiency of the mixture of superheated air and steam. As an attempt to explain what occurs, it has been suggested that the air tends to form an envelope

to the steam particles which resist the tendency to condensation which would otherwise occur, as temperature and pressure fall during expansion. It appears to be more probable, however, that, owing to the fact that the compressed air itself contains great heat, and its temperature may be higher than the temperature of the saturated steam at high pressures, such as 180 lb. or 200 lb. per square inch, the mere admixture of the air with the steam exercises to some degree a superheating action upon the latter, so that the superheating of the mixture with an apparatus that for steam alone will give only a moderate degree of superheat is enabled to give a higher degree of superheat.

The system has been applied in several ways with, we are informed, substantial economy—indeed, a saving of as much as 15 per cent. to 20 per cent. is claimed, and it is stated that even greater economies have been obtained.

For the present, however, it is the application of the system to locomotive engines that is in question. For several years a number of small engines have been fitted some of them having been used for exhaustive trials on a testing plant, while one or two larger engines have been used in regular service on main railways for trial in every-day work. About two years ago, by arrangement with the North British Railway, a standard goods engine and, more recently, one of the large "Atlantic" type express engines of that line, have been fitted with the apparatus, the former having been used extensively in every-day work, while the latter was exhaustively tested. The cut on the preceding page shows the general arrangement of the apparatus.

The air compressing cylinders are arranged tandem to the steam cylinders, and the pump pistons are operated by tailrods, the design being such that the air is supplied substantially at 200 lb. per square inch (the steam pressure). From the air pumps the air passes to the box superheater in the smoke-box, to which the saturated steam from the boiler also passes, and is there admixed with the steam. Here the mixture is superheated, afterwards passing to the working cylinders. The superheater is of simple type, comprising mainly a chamber having smoke tubes in line with, and abutting against the ends of the boiler tubes, and with diagonal partitions as shown whereby the mixture of steam and air is forced to follow a zig zag path from the upper side portions of the superheater to the lower central portions thereof. The air pump cylinders are water-jacketed, the circulating system being connected with the water tanks in the tender.—*The Engineer*, London.

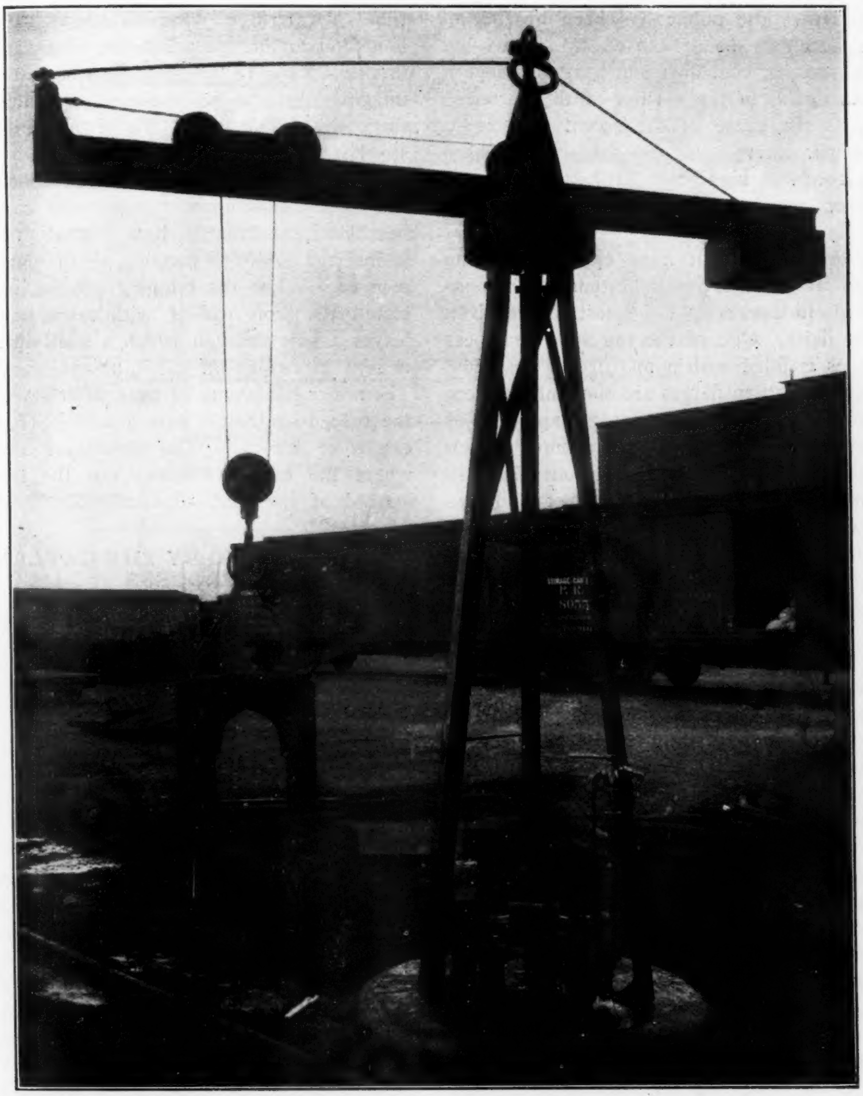
POWER VALUE OF AIR AND GAS

The suitability of a gas and air mixture for supply of a gas-engine or a blast furnace depends on its thermal value, pressure, temperature, and moisture. These quantities are continually varying, and a simple method of testing the quality of the mixture is desirable. Herr W. Heim points out that when the proportions of gas and air can be varied at will it is only necessary to withdraw a small constant volume of the mixture and to ignite it, and to determine by repeated experiment which proportions give the highest flame temperature, as the mixture with this proportion will be the most efficient. The temperature indication can be conveniently carried out by means of an electric pyrometer and galvanometer. By connecting such an apparatus to a small chamber in connection with the gas-engine cylinder, the adjustment of the proportions of gas and air to meet the varying conditions may be made with precision.

A PORTABLE AIR OPERATED JIB CRANE

The half-tone shows a portable jib crane the invention of H. H. Maxfield and G. C. Gardner, Jr., Mr. Maxfield being Master Mechanic of the shops of the Pa. R. R. at Trenton, N. J., and the crane being shown in actual use in the railroad yard at that point. The crane has been in service for two years and has completely demonstrated its efficiency, reliability and general usefulness.

The half-tone shows the entire device so completely that little needs to be said in the way of description. As here shown, the crane is used for light local work in connection with a large dominating traveling crane, the latter picking it up by the loop at the top, depositing it wherever required, and moving it at a moment's notice from place to place. The round, flat base here shown may of course be replaced in construction by a rectangular or other form, and may be provided with wheels to run on a track or elsewhere.



PORTABLE AIR OPERATED JIB CRANE.

The crane as here shown was designed to lift 1,000 lbs. at the end of the jib without any support or bracing, and, as a matter of fact, has so lifted 1,100 lbs. The carriage, with or without a load, is easily movable in and out upon the beam, and the entire upper part rotates without friction, being carried upon conical friction rollers having horizontal axes, a similar set under the flange also preventing the head from rising or tipping, and vertical rollers also keeping the parts always concentric. The power is furnished by an Ingersoll-Rand rotary air motor geared with a single reduction to the hoisting drum, which is so located that when the wire rope is in the middle of the drum length it is exactly vertical and central, corresponding precisely with the location of the sheave overhead. The hoisting and lowering is controlled entirely by the single valve and there are no levers or other devices to handle or look after.

BLOWN-OUT SHOTS IN COAL MINES

For years the public has been hearing of mine accidents being caused by "blown-out shots" igniting coal dust and gas, and since it figures again, in the verdict of the coroner's jury, as the cause of the recent disaster at Marianna, interest in the subject has been stimulated to a high point. What is a "blown-out shot" and how does it operate to do damage?

At the government mine explosive testing station at Arsenal park, Pittsburg, demonstrations in answer to this question are given almost daily. One of the big steel chambers or tubes is filled with a mixture of coal dust and gas, and then flames are shot into it from a cannon; that is, there is an explosion of powder or fulminate in the cannon, which operates the same as a "blown-out shot" in communicating flames to the dust and gas charged chamber. In a mine the shot, instead of being blown out of a cannon, is blown from a six-foot chamber, an inch and a half in diameter, that has been bored into the solid block of coal. This, of course, occurs only when the things do not work properly. It will be seen, however, with what force a charge of powder will shoot from such a hole; just the same as if it were coming from a rifle.

This will be still better understood by the layman when the method of blasting down coal is explained, using the Marianna mine as an illustration. This mine, being new, consists only of entries, nine feet wide. The vein averages six feet in thickness. In taking out the coal the miners "under-cut" a section of the solid block with a machine, which takes out about six inches of coal from under the block and as a rule this under-cutting is entered into the solid body about six feet. This is to enable the forcing down of the coal by a blast, if it were not for the under-cutting, of course, the explosion not only would be more dangerous to the men, but less effective in taking out the coal. Something has to give way when the force of dynamite is released within the enclosure. The undercutting provides for this and, in case of the entries of the Marianna mines, enables the blasting down of the coal in blocks about nine feet long and six feet square.

After the undercutting is completed the miner, with an augur, bores into the block of coal at the top a hole an inch and a half in diameter and six feet deep. The fulminate tube or cartridge, which is about 10 inches long and an inch in diameter, is pushed into this hole, clear to the end. The layman might imagine that the hole would be drilled into the coal at about the middle of the block. Instead it is located at one of the sides.

Its force jars down the entire block that has been undermined. After the cartridge has been placed in the hole a small iron rod is inserted and the tamping in of clay commenced. When the tamping process is completed the iron rod is withdrawn and this leaves a hole through which a squib-like fuse is sent in to put off the fulminate cartridge. The miner has plenty of time, after starting in the fuse, to retreat a safe distance before the explosion occurs. "The blown-out" shot is where the explosive blows out the tamping instead of the coal.—*Connellsville Courier.*

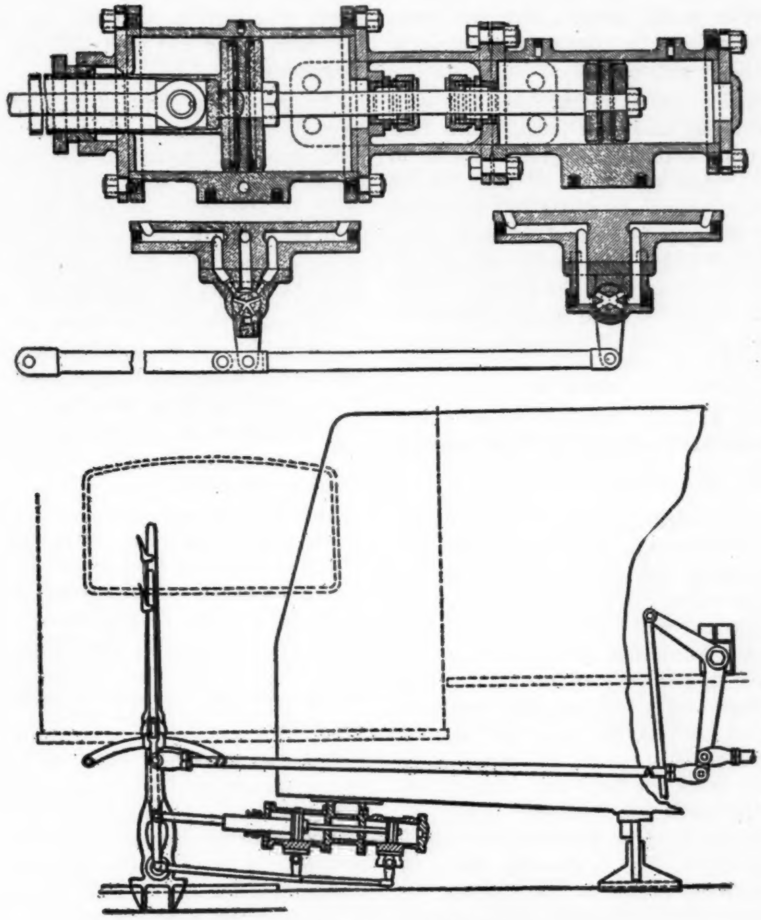
THE SAVING BY THE GAYLEY PROCESS

The original plant was installed by the Carnegie Co., at the Isabella furnace, Aetna, Pa. The moisture in the air is a factor which affects the character and quantity of iron produced, and, as most operators of air compressors are aware, is equally important in realizing the efficiency of utilization of air in this development.

The plant installed was of 450 tons refrigerating capacity; that is, there were two machines capable of producing refrigeration equivalent to the melting of 450 tons of ice in 24 hours. The moisture content removed from the blast was 40 gal. per minute for each grain of water vapor per cubic foot of air content, and the water vapor often rose as high as 8 grains per cubic foot and possessed an average of considerably over 5 grains.

Over 10 tons of water were removed per day, and the speed of the blowers was reduced, with a reduction in horsepower of from 2,700 to 2,013, a saving that more than operated the refrigerating machines, for at their maximum capacity they required only about 530 hp., and generally about one-third of this.

The air consumption was cut from 40,000 cu. ft. per minute to 34,000 cu. ft., and the iron production was increased from 350 tons to 450 tons per day, with a diminution in coke consumption of 2,100 lb. to 1,730 lb. per ton of iron.



PNEUMATIC REVERSING MECHANISM.

HYDRO-PNEUMATIC LOCOMOTIVE REVERSING MECHANISM

In the heaviest and most powerful locomotive in the world, a Mallet articulated compound, built for freight service on the Erie R. R., by the American Locomotive Company at Schenectady, N. Y., and described in a recent paper before the American Society of Mechanical Engineers, one of the interesting features is the hydro-pneumatic reversing mechanism a sketch of which appears in the cut. In the upper portion of the cut the operating cylinders and valves are shown in section, and below that is an outline sketch of the entire apparatus.

There are an air cylinder and an oil cylinder of smaller diameter in line, the common piston rod connecting to the main reversing lever. At a suitable location on the main lever is pivoted a second lever for operating the gear. A forward movement of this lever throws its lower end backward, turning the valves of both cylinders, thus making communication with the rear end of the air or operating cylinder for the air pressure to force the piston forward, and with it the entire gear. The oil cylinder, serving as a lock and regulator, has by this movement established intercommunication between both sides of its piston, allowing the latter to follow the movement of the gear, but securing for it a moderate and uniform motion because of the contracted passage for the oil through the valve. By stopping the movement of the operating

lever the gear moves the main lever up to the given relation to the former, and then automatically shuts off the air supply and locks the oil cylinder piston.

In unlatching the operating lever the same movement raises the main latch, which cannot drop until again in the given relation to the former, when the valves of both the air and the oil cylinders are closed and a positive locking of the gear is secured, in addition to that of the oil lock. The handle part of the main lever is necessary for the purpose of operating the engine by hand in the absence of air pressure or in case of derangement of the gear.

BETTER LIGHT AND AIR FOR MINES

By A. Cressy Morrison, Chicago.

For several years acetylene has been used in miners' lamps in France, Germany and Belgium to a large and steadily increasing extent, until at present it is used almost exclusively in over 200 mines and by approximately 50,000 men. The light is satisfactory and saves nearly 50 per cent. of the cost, giving more and better light. Mining engineers have been more or less familiar with this fact, but the introduction of acetylene into mines up to the last two years has been very slow in this country. Its use is now, however, coming to be recognized as an important advance, and it promises shortly to replace all other means of mine illumination, except in special cases. It is seldom that an improvement in quality or advantage is accompanied by reduction in cost, but the paradox is a reality in the case of acetylene.

Candles, which are largely used throughout our Western mines, remove seven times and kerosene five times as much oxygen as acetylene. The products of combustion given off by candles are 10 times and from kerosene 9 times as much as that given off by acetylene. The difference is therefore enormous. The actual amount of illumination given by candles and kerosene is lessened by a very large percentage by the smoke and mist which so rapidly accumulate, whereas all the light given by acetylene reaches the point to be illuminated without any interference whatever.

It has been found in actual experience that in entries which are 60 to 70 ft. ahead of the air, there is not the slightest particle of smoke from an acetylene lamp and the entry is just as clear at the end of a shift as it is at the beginning.

An interesting thing about acetylene is the tenacity of the flame. It is not easily blown out, the rapid motion of the miner will not cause it to flicker badly, and it burns brilliantly in an atmosphere so foul that candles fade and go out. In fact, acetylene will not deprive the miner of light until the atmosphere is so bad it will not support life.

For underground surveying and mine inspection, the use of acetylene is of great importance. Maps and records escape the usual accompaniment of grease and smudge. The acetylene flame is so small and clear that it affords an accurate point on which to sight instruments.

Another use for acetylene in somewhat larger units is found where the rays are concentrated by a reflector, in which case a brilliant illumination can be thrown into inaccessible places where distant bays, high backs, caved places and other difficult and otherwise hidden parts of the mine can be explored with convenience and in case of emergency without danger.

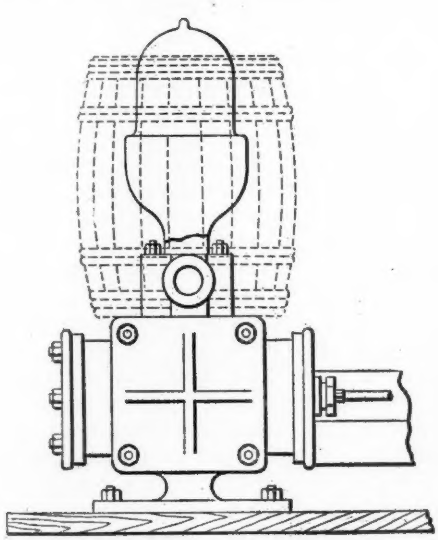
In actual practice it has been found that 4 oz. of calcium carbide at 4 cents per pound will give nearly 10-candle power clear illumination without smoke for 5 hr. One-half pound, or 2 cents' worth, will give the same illumination for 10 hr. Candles in many parts of the country, counting four candles to the 10-hr. day, would cost 5 cents per day.

Acetylene miners' lamps are now frequently found in mines throughout the country, Pennsylvania, New Jersey and Illinois leading, though many other States are using the new light. The greatest number used by any one concern in its mines is probably by the New Jersey Zinc Company of New York, which has adopted acetylene illumination for all its mines. The number of miners' lamps in use in the mines of this company is about 3,000, and it has been found in practical use that the saving is at least 2 cents per day for every miner. The whole method of using acetylene is so simple and the lamps now in practical use are so satisfactory that the subject of better illumination in mines is worthy of the attention of every mine owner and engineer.

CYANAMID, OR LIME-NITROGEN

Calcium Cyanamid, generally spoken of commercially as simply cyanamid, is one of the most important fertilizers which science has brought within easy reach of the agriculturist. It is a granular, minutely crystalline substance, free from fine dust, and stores indefinitely in bags or bulk. It is said to mix with all other fertilizers in any proportion with no coalition of heat, no liberation of ammonia, no reversion of water soluble phosphoric acid, no reversion of citric phosphoric acid, and no change in weight.

Coke and lime are used in the manufacture, with the aid of an electric furnace, the resulting compound being in turn pulverized and combined in a second electric furnace with nitrogen obtained by the evaporation of liquid air. The final compound is calcium cyanamid or lime nitrogen, a nitrogenous material whose ammonia is direct from the atmosphere.

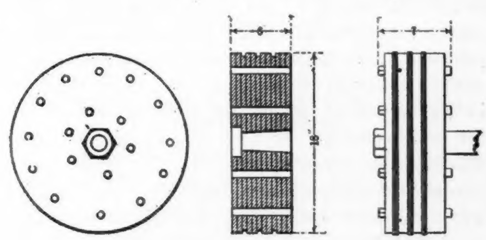


CONCRETE AND A BROKEN AIR CHAMBER

The cut herewith, reproduced from the American Machinist, tells the whole story of how concrete helped a contractor to keep his work going. Away back in the country a water power plant was being built to electrify a town down the valley. A steam pump was keeping the water out of the excavation and an unlucky swing of the derrick boom caused a loaded bucket to hit the air chamber of the pump and broke it off as shown. It was miles to a repair shop and a delay of several days seemed inevitable, but a way out of the trouble was quickly found. The air chamber was put back in position, an empty barrel, minus both heads, was placed over it, with a notch cut out of one side to clear the discharge pipe, holes and openings were plugged and then the barrel was filled with concrete. After waiting over night and the next day for the mass to harden, the pump was started and it ran all right until the work was finished.

A BREAKDOWN AND A TEMPORARY STEAM PISTON

The sketch herewith, adapted from *Power and the Engineer,* shows an emergency piston used in the steam cylinder of a disabled air



compressor. The original piston was wrecked when the heads of two follower bolts broke off and fell into the clearance space. The spider was split and the follower plate was broken. The air from this compressor is in constant demand, so a temporary piston was constructed as follows:

We sheared out 12 plates of 1/3-inch tank steel in circles 18⅛ inches in diameter and bolted them together, as shown, by eighteen ¾-inch bolts. These were drawn up as tightly as possible and the piston put in a lathe. The taper hole in the hub was bored out to fit the piston rod and the piston turned down to the proper size. Three grooves were turned in the surface, ⅝ inch wide and 9/16 inch deep, and high-pressure spiral packing was forced into the grooves. The bolt heads and nuts projecting through the outside plates were turned off so as to make the piston 7 inches thick, the dimension of the broken piston.

The piston was then put on the rod, fitted into the cylinder and run for four or five days, when the new piston was put in. The tem-

porary piston, when taken out, was in good shape, excepting the packing, which was pretty well used up.

The steam pressure was 160 pounds, with 100 degrees Fahrenheit superheat. The piston was rather heavy, but it did the work and no damage was done to the cylinder; in fact, the surface was finely polished when taken out.

CONSTITUTENTS OF THE UPPER AIR

Teisserenc de Bort has been making a study, as interesting in its methods as in its results, of the constitution of the upper atmosphere, and especially of its richness in helium, argon, and the other gases. His investigations were confined to the permanent isothermal stratum which extends from the height of 26,000 feet to that of 46,000 feet above sea level, and the origin of which is yet unexplained. If the upper atmosphere differs essentially in composition from the air near the ground, the specific differences ought to show most clearly in this elevated isothermal stratum, which is not contaminated by the ascending and descending currents caused by cyclones and barometric depressions. The specimens of air were collected by a very ingenious method. A glass tube, which had been exhausted of air and sealed by fusing its pointed ends, was attached to a sounding balloon in such a manner as to avoid the possibility of absorbing hydrogen leaking from the gas bag. When the balloon attained a certain altitude the closing of an electric circuit by the barometer or by the clockwork of the meteorograph caused a little hammer to fall and break one end of the tube. Air entered and filled the tube, which was then sealed by the automatic action of an accumulator, the current of which heated to redness a platinum wire coiled round the broken end of the tube and fused the glass by the heat thus produced. The quantity of air that can be collected in this way is too small for quantitative chemical analysis and can only be analyzed qualitatively with the spectroscope. Two methods have been employed. In one, all the constituents of the air, except helium and neon, are absorbed by charcoal. In the other method, the argon is separated first. Argon and neon were detected in all specimens collected at elevations between 26,000 and 46,000 feet. The yellow line of helium appeared in the spectra of all the specimens, except one which was collected at the greatest height attained, about 46,000 feet. The presence of krypton could not be determined with certainty.—*Scientific American.*

THE ELECTRIC AIR DRILL AT HIGH ALTITUDE

The following, translated and abstracted from *El Comercio,* Lima, Peru, tells of the successful operation of two Electric Air Drills at the Germania mine of Lizandro A. Proano, in the Huarochiri district:

Owing to the hardness of the rock at the Germania mine—it can be considered the hardest in Peru, making the use of wood unnecessary—the progress made in the veins of the mineral was slow, and the miners claimed that the rock was too hard to be drilled satisfactorily by machinery. Besides, the altitude—which is almost 16,000 feet above the sea level—the bad roads, and the distance from the railroad were great obstacles to the use of machinery of any class.

The circumsfances induced Mr. Proano to look into the employment of a drill which would work on an entirely new principle and which promised to solve the difficulty; this was the Electric Air drill. The complete installation as adopted comprised a 45 kw. General Electric generator driven by a direct connected Pelton water wheel, and two 5 h. p. Electric Air drills, these being the largest manufactured.

The plant was put in running condition a few days after its arrival, Mr. Dick of the house of W. R. Grace & Co. taking charge of this work and also that of instructing the operators. They grasped the management of the machines so rapidly that in a short time the drilling of the principal tunnel was under way, working with but one drill and advancing at the rate of a meter per day, thus doing away with the idea of the miners that the rock was too hard for the use of machines. As the progress which had been made by active hand work was only at the rate of 3 meters per month the advantage gained by the use of the drills was sufficiently evident.

The principle upon which these drills work is very simple. A small electric motor is mounted on wheels, so that it can be moved along the tunnel on the car tracks, and directly connected to the motor is a pulsator which

does the work, but in a different way, of the compressor formerly employed. The pulsator does not compress air continuously, but the two cylinders each compress a cylinderful of air alternately, these cylinders connecting by separate hose to the two ends of the drill cylinder. One cylinder drives the drill piston forwards and the other backwards, the same air being used over and over.

The advantage of this system can easily be seen. The air at an altitude such as that where this mine is located is very thin and has only a pressure of 8 lbs., while at sea leved the pressure is 14.7 lbs., so that if a compressor of the ordinary type was employed it would require to be very large and would consume much power. The Electric Air drill uses only one-third the power that an ordinary air drill uses. Large air pipes are not required in the mine, but only the wire, which can be used also for lighting and other purposes. These drills promise positive advantages to the national mining interests of Peru, because of the saving of labor—which is scarce in Peru—and above all of the cost of operating.

SOME TYPICAL WASTES

The following occurs in a paper by I. C. White, State Geologist of West Virginia, read before the American Mining Congress, Pittsburgh, Dec., 1908.

It can do no harm to recall some of the sins of waste committed by your people in the past, since many of these still persist. The citizens of Pennsylvania, and especially of the Pittsburgh district, have already wasted more of their precious fuel supplies, both solid and gaseous, than they have ever used. More than thirty thousand beehive ovens continue to consume almost within sight of your great factories, one-third of the power, and all of the precious by-products locked up in the finest bed of coal the world has ever known, and of which, as we have seen, you have such a limited supply. The quantity of natural gas, the best of all the fuels, which Western Pennsylvania has wasted from the many thousands of wells drilled within her borders, vastly exceeds in value all of the petroleum she has ever produced. Not satisfied with thus despoiling your own fair commonwealth of its most precious fuel possession, some of your most powerful corporations, with headquarters in Pittsburgh, have been the principal agents in wasting unnumbered billions of cubic feet of this precious fuel in your sister states of Ohio and West Virginia. The general superintendent of one of your great gas companies told me only a few days ago that he had personal knowledge of one well in West Virginia from which twelve million feet of gas escaped daily in producing only four barrels of oil, and this spectacle of wasting the heating value of 12,000 bushels of coal daily, together with the *power to deliver itself free of charges for transportation* to Pittsburgh's factories, was at that time not an isolated case, but only one of hundreds. During this riot of waste, one of your great gas companies put into its lines in West Virginia nearly one hundred million cubic feet of gas daily and delivered in Pittsburgh *much less than half that quantity,* the larger portion having escaped into the air through the defective joints of cheap and imperfect pipe line construction.

A PHILLIPPINE SUBSTITUTE FOR LIGNUM-VITAE

A substitute for lignum-vitae is said to have been discovered in the Phillippines. In 1906 such demands had been made. on the West Indian forests for this wood that it was suddenly discovered that the supply of the Lignum-vitae tree had been almost exhausted. Consternation seized the manufacturers who were constantly making use of the product and they began writing to other parts of the world to learn whether there were other available forests of this valuable tree and, if not, what was the nearest substitute that could be obtained.

Major Ahern of the Phillippine Bureau of Forestry states that a wood answering the requirements has been found. This wood is called Mancono. Its technical name is Xanthostemon verdugonianus, Naves.

The Mancono tree grows in considerable abundance in northeastern Mindanao. Small areas contained almost pure stands of it. The wood is so heavy and hard that it is difficult to cut, and the splitting of a log of it is almost impossible.

However, it grows in places easily accessible to those wishing to work it, being usually found along steep slopes near beaches whence it can be shipped by water transportation. Also, as it is only desired in short lengths,

work on it can all be done in the forests where it is cut and the material can be easily handled.

The wood of the Mancono tree, even in the tropics where rot and decay are so ready to seize on all perishable materials, is practically indestructible. White ants, the curse of the tropics, do not attack it. This quality has already made the wood esteemed by many of the Filipinos in the southern islands who use the cumbersome logs for posts and ground timbers.

The heartwood of the tree is uniformly reddish black, but after a number of years of seasoning it turns a black walnut color. Like all Philippine hard woods, it takes a fine polish.

A LESSON IN PIPE CORROSION

Mr. Edward K. Judd, Instructor in Mining, Columbia University, tells, in The Engineering and Mining Journal, of a costly experience with a compressed air pipe line. At a certain group of bituminous mines, he says, a very complete and expensive air-compressing plant was erected in a central position, and the compressed air was to be carried to the mine openings through lines of 10-in. wrought-iron pipes. One of these lines, nearly one mile long was laid for part of its distance in a trench dug along the side of the railroad yard. This yard had previously been graded and ballasted with washery waste, consisting principally of slate, but carrying a large percentage of sulphur.

When the compressors were started, about six months later, it was found, on investigation, that the portion of the pipe line through the yards had in the meantime been so completely corroded, in spots, as to be totally useless. The destruction of the pipes is obviously explained by the oxidation of the iron sulphide in the washery waste, with its accompanying liberation of sulphuric acid. Corrosion occurred in spite of the fact that the pipe was carefully bedded in clay.

In replacing this pipe line, the company has wisely laid the pipe, carefully painted with asphalt over the surface, supporting it at intervals on wooden blocks and stones. As a one-mile length of wrought-iron pipe represents an outlay of about $5000, the saving to be effected in this way is quite apparent.

IRON DUST AND FAST COLORS

A Scotch manufacturer with an established reputation for making black goods guaranteed always fast color, proudly invited a chemist friend to see his mill. Reaching the weaving room the looms were making such a terrific racket that they could not talk. When outside the chemist asked, "What's the matter with your looms, they make a fearful noise?" The weaver whispers, "That's the secret, but I don't mind telling you I have found out by experience and experiment that the noisier my looms, the faster are my colors." "Give me a piece of the undyed cloth," asked the chemist. Examination showed him that the wear and abrasion of the metal parts of the looms had liberally sprinkled the cloth surface with iron dust, which went with the cloth to the dye tubs, and here was the secret of the fast color. The chemist, for a consideration, of course, gave the manufacturer a solution to mix with his dye and thus fix his color,—certainty of results without noise. Scientific method versus untutored experience slightly tinged with superstition.

HOW GAS ENGINES WORK

The following has been devised in the way of an explanation for the non-technical reader of the power developing operation of the gas engine:

Let us set a spiral spring on a platform. If we press down this spring and release it, it will, disregarding friction and heat losses, push up as much weight as was required to push it down. Suppose now that, when compressed, we could suddenly stiffen the spring. It would then lift more in opening out than was required to compress it, and the difference will be a gain in useful work. In a gas-engine we draw in a piston-full of air with some gas. The piston compresses this mixture, just as we compress the spring, and when it is thus compressed an electric spark fires the mixture, and its sudden burning greatly increases the pressure, or stiffens the spring, and drives the piston back with greater force than was required to compress the cooler mixture.

A company has been formed for boring another long tunnel under the Alps. It will be 28 miles long and it is estimated that the work can be done in three years.

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FOR THE AFTERCOOLER

Explosions more or less disastrous, though not generally attended with loss of life, are more frequent than they should be in compressed air practice. Undoubtedly most of such accidents are avoidable, but the knowledge of the conditions essential to safety has been disseminated more slowly than the air compressors have been distributed, so that the frequency of compressed air explosions has increased rather than diminished, and naturally the explosions occur most frequently in connection with the lines of compressors most numerously represented.

The explosions which occur are as a rule not due to the pressures carried and the weakness of the enclosing metal, and they are in fact as frequent with air of comparatively low pressure as with the higher pressures. We have noted quite recently an accident of a typical explosion where the air pressure was only 17 pounds. It is generally conceded that the explosions spoken of are caused by the formation of an explosive mixture of compressed air with a volatilized and inflammable constituent of the oil used for lubrication. For the formation of the explosive compound in this way heat is necessary, and for its ignition with disastrous results more heat, so that high temperatures rather than high pressures are what to avoid or prevent. There is at this point nothing more suggestive of safety than the aftercooler.

In connection with continuous compressed air service, as in operating an extensive mine, or in driving a long railroad tunnel, more attention should be given to the cooling of the air as it leaves the compressor. Aftercoolers have not been generally adopted, or, indeed, even advocated or recommended, being too often thought of, if at all, as an unnecessary and unprofitable refinement of practice; and, yet, they are surely worth while. There are few cases where they would not be found to pay for themselves, contributing as they do in more than one way to economy and safety of operation.

Compression, after all, in all our compressor cylinders is nearly adiabatic. Water jackets are necessary to keep the metal surfaces approximately cool to avoid abrasion, but those surfaces have little effect in cooling the mass of air at any instant under compression, and some compressors deliver the air hot, some hotter, none cool.

If an efficient intercooler is placed as near as possible to the compressor cylinder, and if the air is by this means immediately cooled, its volume is reduced to the minimum and the air is then in the condition most favorable for the deposition of moisture. If the opportunity is then provided in a suitable and sufficient air receiver for the entrained moisture to precipitate no complaint from that cause should arise later in the ultimate use of the air for any purpose. The reduction of volume effected by the aftercooler would often make smaller diameters of piping permissible or reduce the friction loss and pressure drop, and the possibility of disastrous explosions would be practically eliminated.

AN EXPLOSION IN A COMPRESSED AIR MAIN

The following comprises the essential portion of a letter by Mr. J. A. Burgess to the *Mining and Scientific Press,* San Francisco, giving an account of the explosion of a compressed air main in the Mizpah mine of the Tonopah (Nevada) Mining Company, and embodying valuable suggestions as to the conditions under which such an explosion could occur and the best means of prevention. The italics are ours, marking one or two points which cannot be too much emphasized.

The plant in question consists of two 2-stage compressors, one a Fulton compressor, cylinders 25 and 15 by 18 in., running 120-125 strokes per min.; the other an Ingersoll compressor, type D2, cylinders 22¼ and 14¼ by 18 in., running 120-125 strokes per minute. Both compressors have unloaders of the throttled intake type, are water-jacketed about the cylinders, and have inter-coolers between the low and high compression cylinders. At the time of the explosion the compressors were connected with two 4 by 10-ft. receivers, one for each compressor, and the two receivers were connected to the main. Since the explosion a receiver, 6 by 16 ft., has been added to the system.

The explosion took place on the evening of a fair day, at 6:30 p. m., about 45 minutes after starting the compressors. It occurred in the 6-in. main, between 100 and 400 ft. from the receivers. The explosion was violent, and burst open most of the pipe between the 300-ft. level and the surface. The woodwork in the shaft to which the pipe was fastened did not show any scorching, thereby indicating that this portion of the pipe was not excessively hot at any time prior to the explosion. The usual working-pressure is 90-95 lb., but at this time it was only about 80 lb. The compressors were known to be working hot, but as no thermometers were in use it is not possible to state the temperature. In the attempt to improve conditions, the cylinder-oil being used was changed to one having a higher flash and ignition-point, but even with this oil, *combustion, but not explosion,* has occurred in the receiver attached to the Ingersoll compressor.

Among the unfavorable conditions under which the plant works are the following: An atmospheric temperature frequently in the neighborhood of 100° F. during the summer; an altitude of 6,000 ft.; and an Ingersoll compressor *designed for sea-level.* The Ingersoll compressor was installed first, later the Fulton was added, and various other minor additions were made from time to time as their need was felt; consequently the plant lacks the uniformity of design it would have had if it had all been installed at one time.

The cause of an explosion of this kind is obviously the presence in the system of an inflammable gas, or possibly dust, mixed with air in such quantity as to render it explosive. The presence of an inflammable gas may be accounted for in several ways:

1. It may be generated from an oil of low flash and ignition-point by a not unreasonably high temperature.

2. It may be generated from an oil of high flash and ignition-point by an excessive temperature.

3. It may be generated by high temperature from a tarry deposit of partly destroyed oil, carried over from the compressor. This is sometimes deposited in the pipes or receivers of compressors.

Among the ways of accounting for the presence of fine carbonaceous dust are:

1. Dust from outside sources, such as coal-dust from the blacksmith shop, drawn through the intake. This would probably be insufficient by itself to cause explosion.

2. Smoke generated by over-heating of oil or tarry deposits. This would doubtless be accompanied by gas, and may be considered as a part of the gas, as far as its effects go.

Ignition of the explosive mixture may have originated, in the Mizpah explosion, in the following places:

1. In the main where the explosion occurred. This seems improbable. The timbers

show no charring such as would be caused by hot pipes.

2. In the receiver. This seems possible.

3. In the pipe between the compressor and the receiver. This seems possible. It is here that a black sooty or tarry deposit is sometimes found.

4. In the cylinders or in the outlet pipe, due solely to a sudden increase of temperature caused by leaky or sticking valves, improper unloading devices, or by an outlet-pipe choked with carbonaceous deposit.

Wherever ignition occurred, it may have been caused by the catalytic action of a porous deposit of carbon, even though the general temperature were not high enough to ignite the gas under ordinary conditions. To quote from Ostwald's "Chemistry": "The oxidation of many substances by free oxygen is greatly accelerated when charcoal is present. . . . Gases which under given conditions act only slowly on one another can be made to act more quickly with the help of charcoal."

If ignition occurred in the compressor, or in the outlet-pipe to the receiver, or in the receiver, we must account for the explosion occurring only in the main and not in the receivers. I would explain this by assuming that the receivers were filled with a mixture of gas and air in such proportions as to be inflammable but not explosive; that the mixture was explosive only in the main, and that combustion of the gas in the receivers was comparatively slow, in the nature of a flare, and served to transmit ignition to the mixture in the main. In a letter on this subject, Prof. Edmund O'Neill says: "The most favorable mixture is about one part of oil vapor to seven parts of air. As the proportion of oil vapor or air recedes from this proportion the violence of the explosion diminishes until there is no danger either way. The most violent explosion may occur with less air or with more air, according to the composition of the gas." From this it will be seen that we can have a gas-and-air mixture spread throughout the receivers and pipes, varying from a merely inflammable mixture in one place to a highly explosive mixture in another place. The heat of the flare would raise the pressure in the receiver and thus increase the pressure of the mixture in the main and render its explosion all the more violent.

The precautions deemed advisable are as follows:

1. First, where possible, a well designed plant, *built for the altitude in which it is to operate*. With a sea-level compressor working at a high altitude, *too great a proportion of the work is thrown on the high-compression cylinder*. Under this heading come the following details:

(a) Intake-pipe of wood and taking air from a place outdoors as cool and as far away from dust-producers, such as the blacksmith shop, as possible.

(b) Unloader to be of a design that will not cause excessive heating when the compressor is partly unloaded.

(c) Efficient intercoolers.

(d) *After-coolers between the high-compression cylinder and the receiver,* on a compressor that shows a tendency to overheat. This would tend to prevent the transmission of ignition into the receiver, even though gas were formed, and the gas would not ignite spontaneously in the receiver if cooled before getting there.

(e) Efficient water-coolers, where water must be used over again.

(f) Inlet to receivers to be at their top, and outlet about a foot above the bottom. This will insure the air entering the main being clean, and the coolest in the receiver.

(g) Blow-off cock at bottom of receiver.

(h) Check-valve between compressor and receiver. This may save the compressor in case of an explosion or flare in the receiver. [This suggestion, we take it, is little likely to be adopted.—Ed. C. A.]

(i) Recording thermometers and pressure-gauges.

2. Use the best oil obtainable for the purpose, and *as little of it as is consistent with proper lubrication.* It would seem that a good oil, with as high a flash and ignition-point as can be produced with the necessary fluidity, would be the most desirable; for a poor oil would doubtless furnish the condition for explosion at a lower temperature than a good oil.

3. Use well regulated oil-cups with sight feed. If oil is fed in excess of the requirements of the pistons, it will accumulate in the cylinders, when they are unloaded, as there is no opportunity for it to be blown off with the air. In machines where overheating is apt to occur, this gives a favorable condition for gas production.

4. Clean the outlet valves once a week.

A PIPE EXPLOSION AND A RUNAWAY COMPRESSOR

A writer in a recent issue of *Power and the Engineer* tells of a compressed air accident in a railroad shop which wrecked things in general. The accident was a progressive one, the first trouble being the explosion of about a hundred feet of underground air pipe in the yards, which so lowered the receiver pressure as to cause the engine, which was air-controlled only, to run away and burst the flywheel, which was directly in line with a battery of large boilers. They, however, escaped injury.

The primary cause was undoubtedly oil in the pipes, which became volatilized and fired, either by heat or by electricity, the former being more likely.

There are three lessons to be learned from this accident, of which the most important is that an air-compressor engine should not be controlled by air alone, but should be fitted with an auxiliary governor which will act as soon as the speed rises above a certain point. In this way an accident to the tanks or piping, causing a sudden lowering of the pressure to a dangerous degree, would not cause the engine to race. The lowering of the pressure need not necessarily be caused by an explosion; the giving way of a pipe, valve or tank from any cause would have the same effect.

The second lesson is one that is being driven home by dozens of accidents all over the country, and that is, *keep an excessive amount of oil out of the system.*

The third and last lesson is one that is seldom needed, but which in this case was disregarded, though fortunately without serious result. It is that no engine should be so set that the bursting of the flywheel would be apt to crush the boilers.

ELECTRIC AIR DRILL RECORDS

Mr. Wallace F. Disbrow, superintendent of the Merry Christmas lead and zinc mine, Mineral Point, Wis., gives in Engineering-Contracting some interesting data on operating two electric air drills. These drills have been heretofore described in our columns.

The drill, mounted on a tripod or column, is actuated by air from a pulsator, which with an electric motor forms a complete actuating apparatus all under the eye and hand of the drill runner. The Merry Christmas mine has two of these drills. They are of the 4 D size, with a cylinder 4¾ in. diameter and 7 in. stroke. The drill is designed to carry 10 ft. of steel in drilling vertical holes. This makes the work done similar to that of a 2¾ in. steam or air drill.

These two drills have been operated in this mine for the past six months in a rather soft limestone formation. Although the rock was soft, it was exceedingly sticky and a heavy and gummy sludge was formed, making the drill work exceedingly difficult. In fact, so great is the influence of this factor in drilling, that formerly, with 80 lbs. pressure on the old style air drill, it was extremely difficult to put down a hole and extract the 6 ft. drill steel even when the hole was well watered. Mr. Disbrow states that "The electric air drills, with their powerful plunging stroke, are able to handle a 12-ft. steel down to the chuck without a stop if the machine is properly handled. In fact we have noted many times that when the hole was not sufficiently watered, the steel would still go down and keep turning, so that when the hole was finished, it would be almost impossible to extract the steel with a wrench."

This long stroke is an important factor in drilling holes wherever the sludge forms quickly, as the drill point thus helps to keep the bottom of the hole free of the sludge. With a short stroke the sticky sludge hangs much closer to the bottom of the hole, cushioning the blow, and sometimes stopping the drill. To keep the hole well watered in either case is a great help to the drill.

The drills in the Merry Christmas mine are not used continuously. Upon one occasion one drill put down 63 ft. of hole in two hours, the average depths of holes being 5 ft., making a record of 31½ ft. per hour. On another day a drill sunk two rounds of 12 holes each, to an average depth of 5 ft. For this work the drill was set up twice, as each round of holes were shot. This meant the drilling of 120 lin. ft. of holes, the time being 5½ hours, or at the rate of 21.8 ft. per hour, including making the extra set up.

The cost of maintenance of these two drills for six months has been about 20 cts. per day per drill. The principal parts to wear were chuck bushings, hose, front head cup leathers and chuck pins. The hose is the largest item

of renewals, as soon as the slightest leak appears it must be discarded.

The cost of electric power for these drills has been with power at 5 cts. per K.W., for a single drill per day, $1.00, as about 20 K.W. is the average consumption of power.

NEW BOOKS

Compressed Air. Its Production, Uses and Application, by Gardner D. Hiscox. Fifth Edition, Revised and Enlarged, New York, The Norman W. Henley Publishing Company. 665 pages, 9½ by 6½ inches. Copiously Illustrated. Price $5.00. When a book makes its own way to a fifth edition, as this has, commendation is superfluous. Mr. Hiscox, who retained his full mental powers to within a week or two of his death, spent his last days of work in bringing the book up to date. This is a new edition throughout and the revision has extended to every page, eliminating obsolete matter and adding the later developments which have occurred in the various details of compressed air practice.

TRADE PUBLICATIONS

Air Compressors for Industrial Service, National Brake & Electric Company, Milwaukee, 24 pages and cover, 6 by 9 inches. This shows an interesting line of small, compact, motor or belt driven machines for general use, with tables of dimensions, capacities and other particulars.

Our New Product, B. F. Sturtevant Company, Hyde Park, Massachusetts, 16 pages and cover, 9 by 6 1-2 inches. This is Bulletin No. 158 of the Sturtevant engineering series, and deals with the multivane fan which is claimed to be the most efficient commercial fan in the world. A variety of applications are shown.

A FIGHT STOPS A DIVERS AIR SUPPLY

One of the horrors for a diver to reckon with must be the possibility of a stoppage of his air supply. A man working down in a Hell Gate wreck recently had a real experience of this character. Two men pumping air to him engaged in a desperate fight and the pump was stopped. When some other men realized the state of affairs they started the pump but could get no response by the life line. When the diver was hauled up he was unconscious and on removing his helmet heroic efforts were necessary to restore him. We may assume that he went on and took the risk again the next day the same as usual.

NOTES

A new system of Chinese weights and measures has been fixed by law. The unit of length is the "tchi," which is 32 centimeters, 12.6 in. For capacity, the "to" is 10.355 liters, 631.88 cu. in.; and for weight, the "lian" is 37.301 grams, 575.63 grains.

Diamond drilling on the Rand, according to an editorial in the *South African Mining Journal*, Oct. 10, 1908, apart from strengthening the knowledge that the Main Reef does go down, has not obtained adequate return for the vast sums that have been expended in such prospecting.

A handy formula for the horse power of falling water, assuming 80 per cent. efficiency for the wheel, is:

$$HP = hq \times .09$$

in which h is the effective head in feet, and q is the quantity of water in cubic feet per second.

By case hardening is meant the process of carburizing or converting the outer portion of a piece of iron into steel. This is done by heating the iron in contact with some carbonizing substance until a sufficient amount of carbon has been absorbed. The actual hardening is done by suddenly cooling the article in water.

A company has been formed at Buffalo to build a $20,000,000 drainage and power canal from Lake Erie at South Buffalo to Lake Ontario, providing that the federal government consents to the diversion of the water. Buffalo River, Smoke's Creek and Ellicott Creek, in the engineer's plan, will have their currents reversed and flow into the canal instead of into Lake Erie and Niagara River.

Great confusion exists in a misuse of the word "ton." The unqualified term may mean the short ton of 2,000 pounds, the long ton, gross ton or English ton of 2,240 pounds, the

gross ore ton of 2,688 pounds, the miner's ton of 2,500 to 3,000 pounds, the displacement ton of 35 cubic feet, the timber ton of 42 cubic feet, the shipping ton of 40 cubic feet, and a register ton of 100 cubic feet more or less.

The Cartago, the new steamer of the United Fruit Company, is provided with a refrigerating plant of ample capacity, and this is made to contribute to the comfort of the passengers. A push-the-button system is installed connecting the various rooms individually with the cold storage plant, so that no matter how hot the weather the passengers can regulate the temperature of their rooms to suit themselves.

A commission reporting to the Postmaster-General recommends that the pneumatic tubes now in use between main and branch offices in Boston, New York, Philadelphia, Chicago and St. Louis be continued under their present status; that is to say, that the government should not buy the tubes. The contracts under which the tubes are now used (for conveying mail matter) run for nearly eight years longer, and as the service appears to be still in experimental condition, five or six years hence will be soon enough for the government to think of acquiring ownership.

The latest and completest installation of the submarine bell signal system is undoubtedly that upon the new Ambrose Channel lightship which supersedes the Sandy Hook lightship at the approach to the harbor of New York. The bell is operated as usual by compressed air and is struck at regular intervals by a mechanism controlled by clockwork. The signal for this ship is the number 22. The bell strikes two and after an interval of three seconds it strikes two again; then after a silence of twelve seconds the strokes are repeated, and so on continuously.

Sapphires valued at $229,800 were produced in Montana in 1907. The blue sapphire in matrix was worked in the Judith River region in Fergus county. These sapphires, often called Yogo, range in size from minute crystals up to 4 or 5 carats. In color the Yogo sapphires range from light blue to the rich "cornflower" blue characteristic of the oriental sapphire. They make beautiful gems and are highly prized for their color and brilliancy. Probably over 90 per cent. of the sapphire is of good blue color and of gem quality. Occasionally purplish gems are found.

For the past year the Pittsburg & Westmoreland Coal Company has been dampening its mines by introducing steam into the air current at the fan forcing it through the mine in dry weather to prevent the roof from becoming unduly dry. The plan is reported to have worked well last winter and is again being used this year the idea being that of President H. A. Kuhn of the company. By this method the absorption of mine moisture by dry air from the fan is prevented in weather when the outside air is dry.

At Welaka, Florida, is what may be called a double well. It is 309 feet deep and has a casing 110 feet long. The well was first drilled to 160 feet, and from this depth ordinary "sulphur" water was obtained. The drill was then carried to a depth of 309 ft., where it encountered a strong mineral water, having a disagreeable salty taste. In order to use both kinds of water an inner tube was run nearly to the bottom of the well. Both this and the outer casing were connected with pumps, so that ordinary water and mineral water can be pumped at the same time.

Molybdenum is now produced in the fused state by the aluminothermic reaction. It is a metal of gray color, like steel, and has a dense structure. It contains as chief impurity about 1 or 2 per cent. or iron, besides very small quantities of silicon, so that its purity is 98 to 99 per cent. Molybdenum is also applied in the first place for making tool-steel, and is often used as a substitute for tungsten. The percentage in which molybdenum is used for such purposes is much smaller than that of tungsten.

The three big battleships recently launched in Great Britain, Bellerophon, Temeraire and Superb, will consume 3,650,000 lbs. of American lake and electrolytic copper, and 1,000,000 lbs. will be required for each of three more big battleships whose keels are to be laid in England. For account of the men-of-war on the stocks of Continental Europe, 19,000,000

lbs. of lake and electrolytic copper will be needed within a year. The mercantile marine contracts under way in European yards will consume 57,000,000 lbs. of copper within a year.

A committee, appointed by the Scientific Commission of the Aero Club of France, is about to institute experiments to determine who among its members is best fitted physically to resist the effects of high altitudes, and then a systematic effort will be made to penetrate into the zone of atmosphere lying 10,000 meters—32,000 to 33,000 feet—above the earth's surface. The ascensions concerned with this attempt have been called "physiological," because their principle object is to study the vital phenomena of the upper air. Apparatus for the inhalation of oxygen as "a gaseous cordial" will play an important part in the scheme.

An inland waterway 104 miles long is being dredged for the Mexican Government to connect the ports of Tampico and Tuxpan, on the Gulf of Mexico. It is 75 ft. wide and 10½ ft. deep and is only 2 to 5 miles from the Gulf throughout its length. Its purpose is to afford a safe channel for the many small craft engaged in the coastwise trade, which find rough weather and a bar at the mouth of the Tuxpan River a serious obstacle to their business. The United States has still only reached the talking stage for extensive work of this character along the Atlantic coast. The desirability and entire practicability of such proposed work is conceded.

Aluminum is gaining in popularity as a substitute for magnesium in flashlight photography. Its chief advantages is that it is obtainable in very fine powder—much finer than is possible with magnesium. The finest aluminum is that known as aluminum bronze, and is used for making "aluminum paint." The powder is much more easily ignited when mixed with one-and-a-quarter times its own weight of chlorate of potash, but the mixing must be very carefully done with a feather, as friction will sometimes cause it to explode spontaneously. The duration of the flash is about the same as that of magnesium, but the actinic value of the light is rather higher, chiefly on account of the more complete combustion of the fine powder.

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D C.

DECEMBER 1.

905,143. METHOD OF HUMIDIFYING AIR. WILLIAM G. R. BRAEMER, Buffalo, N. Y.

905,210. PNEUMATIC PUMP. CALEB W. MOORE, Vancouver, Wash.

905,211. AIR-COMPRESSOR. CALEB W. MOORE, Vancouver, Wash.

905,291. METHOD OF OPERATING PNEUMATICALLY-DRIVEN FANS. JOHN L. CREVELING, New York, N. Y.

905,292. TRAIN FAN SYSTEM. JOHN L. CREVELING, New York, N. Y.

905,361. METHOD OF PRODUCING AND UTILIZING OZONE. HENRY N. POTTER, New Rochelle, N. Y.

905,387. WATER-SPRAYING DEVICE FOR PNEUMATIC TOOLS. ALBERT H. TAYLOR, Easton, Pa.

905,388. WATER-SPRAYING DEVICE FOR PNEUMATIC TOOLS. ALBERT H. TAYLOR, Easton, Pa.

905,582. AUTOMATIC AIR-BRAKE HOSE-COUPLING. CHARLIE W. RHODES, Buena Vista, Va.

905,584. PNEUMATIC TIRE. FREDERICK RICHARDSON, Providence, R. I.

905,640. AIR AND GAS COMPRESSOR. HERBERT L. BORCHERS, Denver, Colo.

905,642. BICYCLE-PUMP. HARRY C. BROOKS, San Jose, Cal.

905,659. AIR-PRESSURE REGULATOR FOR PNEUMATICALLY-OPERATING MUSICAL INSTRUMENTS. JOSEPH COURVILLE, Detroit, Mich.

905,692. PNEUMATIC HAMMER. CARL R. GREEN, Dayton, Ohio.

905,767. PORTABLE ACETYLENE-GENERATOR. LOUIS TROUBETZKOY, Milan, Italy.

905,778. PRESSURE-INDICATOR FOR PNEUMATIC TIRES. FRANH O. WOLFF, Windsor, near Melbourne, Victoria, Australia.

DECEMBER 8.

905,861. ROTARY AIR-COMPRESSOR. SMEDLEY J. EVERTS and JOSEPH E. BURRIS, Belt, Mont.

905,874. AIR-COOLING DEVICE. GEORGE W. HAVERSTICK, St. Louis, Mo.

905,948. METHOD OF MAINTAINING A CONSTANTLY-OPEN FEEDING-PASSAGE INTO THE INTERIOR OF MOLTEN BATHS. FRITZ O. STROMBORG, Youngestown, Ohio.

1. The method of maintaining a constantly open feeding passage into the interior of a molten bath, consisting in providing a passage communicating with the interior of the bath, and constantly maintaining in said passage *fluid under pressure* in excess of the pressure of the head of the bath but only sufficient to cause a slow bubbling of the pressure fluid through the bath.

905,967. ROTARY BLOWER OR GAS-PUMP. JOHN T. WILKIN, Connersville, Inds.

905,973. MECHANICAL PRODUCTION OF HIGH VACUUMS. JOSEPH ZEITLIN, South Kensington, England.

906,165. PNEUMATIC CARPET-CLEANING MACHINE. JOHN F. RUDD, Kansas City, Mo.

906,234. SUCTION-DREDGE OR THE LIKE. FRANKLIN H. JACKSON, Berkeley, Cal.

906,275. APPARATUS FOR CARBURETING AIR. SEYMOUR W. PEREGRINE, Portland, Me.

906,285. VALVE FOR AUTOMATICALLY AND INTERMITTENTLY INTERRUPTING A CURRENT OF GAS OR LIQUID. GUSTAF VON POST, Stockholm, Sweden.

906,309. AIR-RIFLE AND THE LIKE. HENRY A. C. SCHOBBERT, Stamford Hill, London, England.

906,395. COMPRESSED-AIR WATER-ELEVATOR. ROBERT M. DOWNIE, Beaver Falls, Pa.

906,406. AEROPLANE FLYING-MACHINE. THOMAS H. GIGNILLIAT, Savannah, Ga.

DECEMBER 15.

906,532. METHOD OF PURIFYING MILK, CREAM, AND OTHER LIQUIDS. WIGGO F. JENSEN, Topeka, Kans.
906,559. SELF-PROPELLED AIR-SHIP. GEORG PUM, Vienna, Austria-Hungary.
906,570. AUTOMATIC COUPLING FOR AIR-PIPES. CLARENCE SHEELER, Coatesville, Pa.
906,585. CLUTCH-OPERATING MECHANISM. HARRY L. TURNEY, Portland, Oreg.
906,659. COMBINATION PUMP AND COMPRESSOR SYSTEM. WALTER J. RICHARDS, Milwaukee, Wis.
906,733. WELL-BLOWER. JOSEPH H. McEVOY, Houston, Tex.
906,741. TUNNELING-MACHINE. JOSEPH RETALLACK, Denver, Colo.
906,764. MEANS FOR OPERATING THE RETAINING-VALVES OF AN AIR-BRAKE SYSTEM FROM THE ENGINE. HARRY P. ZACKEY, Martinsville, N. Y.
906,808. FLUID-PRESSURE ENGINE. WILLIAM T. LEWIS, Columbus, Ohio.
906,833. PNEUMATIC SAFETY APPLIANCE OF CARS. ALBERT J. THORNLEY, Pawtucket, R. I.
906,850. PNEUMATIC SURFACING-MACHINE. GEORGE L. BADGER, Quincy, Mass.
906,923. PNEUMATIC CUSHION. VACLAV H. PODSTATA, Dunning, Ill.
907,041. MOTIVE-FLUID-OPERATED ROCK-DRILL. CHARLES M. HAMPSON, Denver, Colo.
907,054. REGULATOR FOR AIR-COMPRESSORS. GEORGE W. HUNNEYMAN, Concord, N. H.
907,096. PORTABLE PNEUMATIC DRILL. ANDREW P. STROM, Cleveland, Ohio.

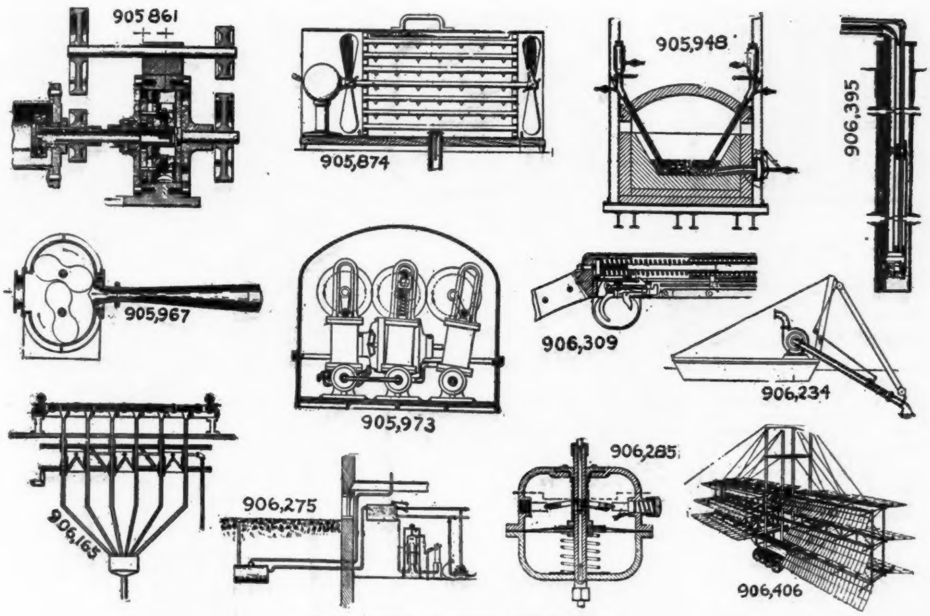
DECEMBER 22.

907,120. AERIAL MACHINE. HENRY S. BOOTH, Manchester, England.
907,180. COMPOSITION FOR PURIFYING AIR. HERBERT RYDER and LYNDON C. WILSON, Newark-on-Trent, England.
907,236. COW-MILKING MACHINE. ARTHUR V. HINMAN and RALPH L. HINMAN, Munnsville, N. Y.
907,341. HYDRAULIC AIR-PUMP. ALBERT S. GRAY, Grand Rapids, Mich.
907,356. SUBAQUEOUS TUNNEL. OLAF HOFF, New York, N. Y.
907,357. METHOD OF SINKING SUBAQUEOUS TUNNELS. OLAF HOFF, Tarrytown, N. Y.
907,392. ASPIRATOR. CHARLES W. NANCE, Sydney, New South Wales, Australia.
907,407. SUBAQUEOUS ROCK-BREAKER. CHARLES L. ROWLAND, New York, N. Y.
907,430. DRILL-HOLE-CLEANING ATTACHMENT FOR HAMMER-DRILLS. DANIEL S. WAUGH, Denver, Colo.
907,446. ACETYLENE-GAS GENERATOR. CHARLES L. BETTS, New York, N. Y.
907,474. COMPRESSED-AIR ENGINE FOR CONDUIT WIRE-DRAWING. HARRY C. DICKINSON, Mobile, Ala.
907,591. AIR-PUMP. JAMES J. GILDAY, Berringa, Victoria, Australia.

1. An improved pump comprising a revoluble cylinder having one or more internal screws attached to or formed integral therewith, said screw or screws having a gradually increasing pitch from the air intake, a central core formed integral with said screw or screws tapered from the air-outlet, an axle on said core journaled in removable bearings on a stationary casing around the cylinder, an inlet pipe attached to said casing and a gland between the latter and said cylinder substantially as set forth.

907,633. AIR-WASHING APPARATUS. LOUIS NAROWETZ, Chicago, Ill.
907,686. AIR-BRAKE APPARATUS. CHARLES E. DUFFIE, Omaha, Nebr.
907,694. MEANS FOR OBSERVING DUST-LADEN CURRENTS OF AIR. DAVID T. KENNEY, North Plainfield, N. J.

PNEUMATIC PATENTS, DECEMBER 1.



PNEUMATIB PATENTS, DECEMHER 8.

DECEMBER 29.

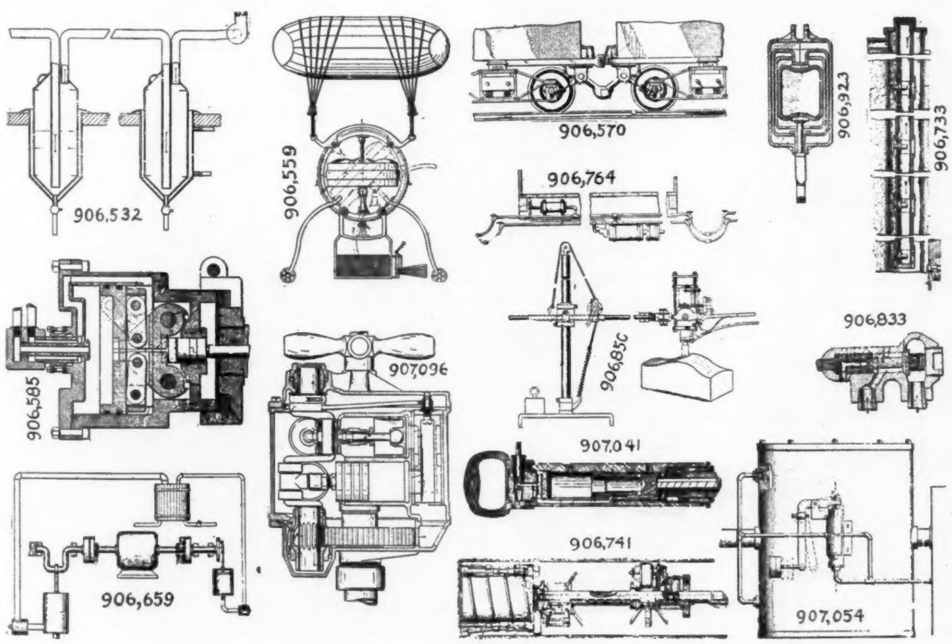
907,853. PRESSURE-APPLYING MACHINE. DAVID A. MURPHY.

907,859. AIR-COMPRESSOR. CHRISTIAN NEUMANN, St. Louis, Mo.

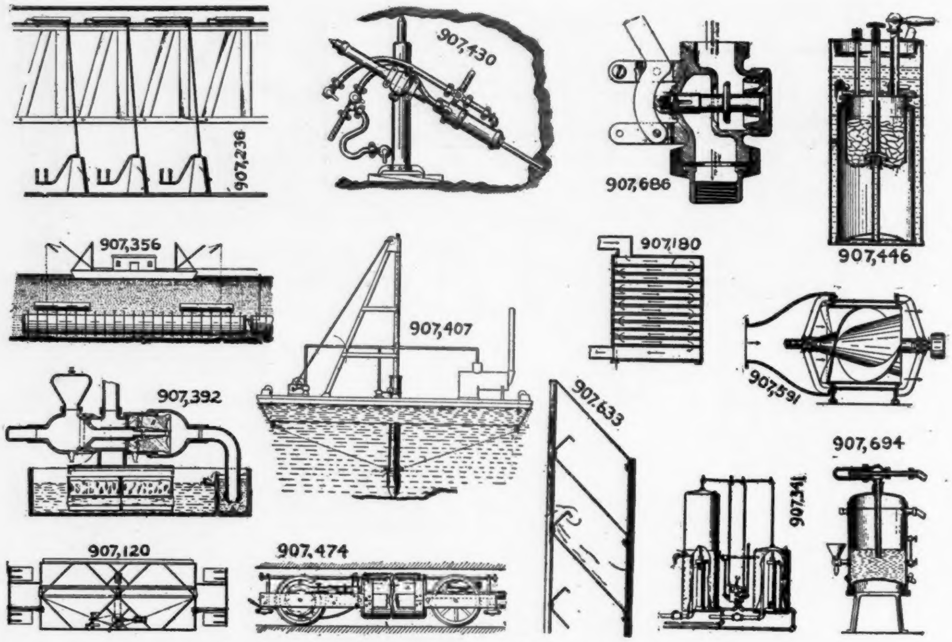
907,884. MOTOR-COMPRESSOR. WALTER J. RICHARDS, Milwaukee, Wis.

907,992. AIR-SHIP. MAX GRUBE, Oakland, Cal.

908,002. MOLDING-MACHINE. CHARLES HERMAN, Allegheny, and MARTIN L. HEYL and HARRY T. FRAUENHEIM, Pittsburg, Pa.



PNEUMATIC PATENTS, DECEMBER 15.

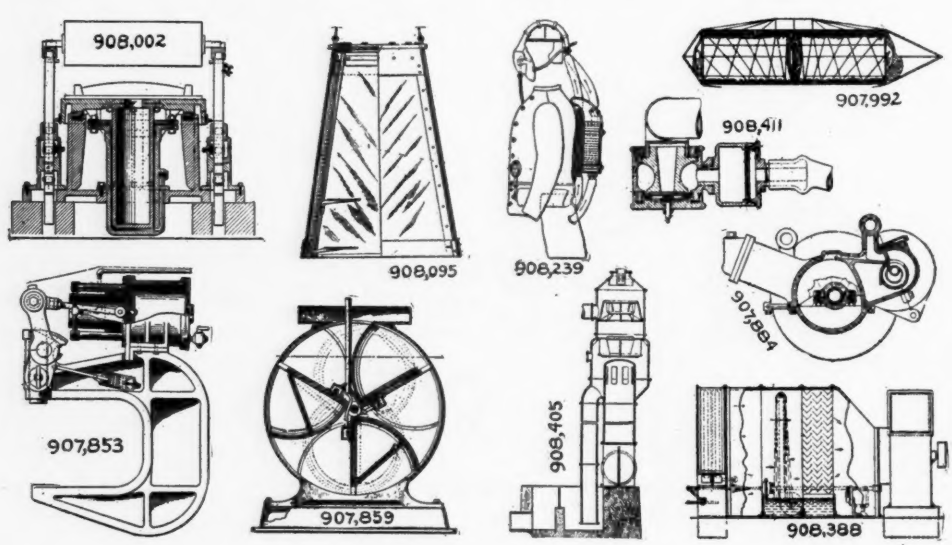


Pneumatic Patents, December 22.

908,095. DIVING-BELL. Edward J. Hassan, East Haven, Conn.
908,239. RESPIRATORY APPARATUS FOR USE IN COAL-MINES AND LIKE PLACES. William E. Garforth, Normanton, England.
908,388. AIR-PURIFIER. William G. R. Braemer, Buffalo, N. Y.

908,405. BAROMETRIC CONDENSER. Axel H. Helander, Pittsburg, Pa.

908,411. COMPRESSED-AIR TALKING-MACHINE FOR PHONOGRAPHS, GRAMOPHONES, AND OTHER SPEAKING-MACHINES. Henry Joly, Paris, France.



Pneumatic Patents, December 29.